Distribution and abundance of non-native red-eared slider turtles (*Trachemys scripta elegans*) and native red-bellied turtles (*Pseudemys rubriventris*)

A Thesis

Submitted to the Faculty

of

Drexel University

by

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in partial fulfillment of the

requirements for the degree

of

Master of Science in Environmental Science

June 2010

Acknowledgements

The following individuals were instrumental in data collection; Pilar Santidrian, Harold Avery, James Spotila, Walter Bien, Chris Urban, Tina Walther, Eugenia Zandona, and Gabriela Blanco. Steven Pearson provided additional expertise in trapping turtles. Field assistance during trapping season was provided by Kim Magrini, Abby Dominy, Dave Steinberg, Raj Patel, Kelly Sanger, Elliot Chiu, Allie Bryne, Dante Proeto, Paul Hildebrand.

The following grants were essential to the success of this project: PA Boat and Fish Commission, Sea Grant, and DuPont Clear Into The Future (through Susan Kilham).

Without cooperation from the following agencies this project would have been impossible: PA Boat and Fish Commission, Silver Lake Nature Center, U.S. Fish and Wildlife Service, John Heinz National Wildlife Refuge and Fort Mifflin.

Additionally, the help of my committee members: Harold Avery, James Spotila, Walter Bien and Gary Stolz, was essential and much appreciated.

Without the support of numerous friends both within Drexel's Biology Department and outside it and the support of my family, this would not have been possible.

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Abstract

Habitat destruction and introduction of non-native species are among the greatest threats to the Earth's biodiversity. The threatened red-bellied turtle, *Pseudemys rubriventris*, historically prevalent throughout the Mid-Atlantic region, is now restricted to a few fragmented wetlands. In addition to destruction of wetland habitat, introduction of the non-native red-eared slider turtle, *Trachemys scripta*, may play an important role in the decline of red-bellied turtle populations. Because the niches occupied by these two turtle species overlap, the invasion of red-eared slider turtles represent a threat to the red-bellied turtle as a competitor for limited wetland resources. In 2005 and 2006 we assessed 52 wetlands throughout Southeastern Pennsylvania for the occurrence of red-eared slider turtles in historic red-bellied turtle habitat. *Trachemys scripta* occurred at 25 of the 52 wetlands. Thus, *T. scripta* are pervasive within the geographic range of *P. rubriventris* in Southeastern Pennsylvania. From 2007 to 2009, I used mark-recapture to determine relative abundances of the two species in different wetlands. GIS-based landscape data was used to determine relationships between habitat degradation and relative abundances of both turtle species. I found a negative relationship between our human impact rank and the relative abundance of *P. rubriventris.* I found a lower relative abundance of red-bellied turtles in wetlands in public parks. There was no significant difference in relative abundance between the two methods, trapping and observation of basking turtles. Four observation visits were sufficient to detect turtles. The data provide wildlife and habitat management agencies important information on the relationship between invasive *T. scripta*, the state threatened *P. rubriventris* and wetland characteristics.

Chapter 1: Introduction

Invasion

Invasive species are a threat to biodiversity worldwide (Vitousek, D'Antonio et al. 1997; Walker and Steffen 1997; Wilcove, Rothstein et al. 1998; Byers, Reichard et al. 2001). Invaders that survive to reproduce in their new habitat represent several potential threats to native species. Invaders can take over habitat occupied by native species or out-compete the native species for prey items or mates (Lockwood, Hoopes et al. 2007). According to Moyle and Light (1996a), ecosystems with high human impact are more easily invaded than pristine ecosystems. Invasive species with similar niche dimensions (i.e. moisture requirements, prey items, temperature tolerances) to native species may be the cause of native species decline or extirpation. Alternatively, the presence of invasive species in an ecosystem may be a result of human disturbance and destruction of the ecosystem.

Pimentel et al. (2000) estimate the economic damage caused by non-native species to be $137 billion in the United States. The cost would be higher if species native to parts of the United States, which have invaded other parts of the United States, were included. Since it is extremely difficult to accurately assign a monetary value to the cost of extinctions caused by non-native species, the $137 billion does not include any cost of extinction. Removal of non-native species is a $20 billion a year problem for over half the National Park Units in the United States (NPS 1997; D'Antonio and Meyerson 2002).

In the United States about 40% of the species on the federal endangered or threatened lists are there mainly due to competition with or predation by non-native species (Wilcove, Rothstein et al. 1998; Pimentel, Lach et al. 2000). Competition or predation is secondary only to habitat loss and fragmentation as a causative agent for the decline that instigated listing of species and most species subject to pressure from invasive species were also affected by habitat destruction or fragmentation (Wilcove, Rothstein et al. 1998). Invasive species can compete directly with native species for resources (Cadi and Joly 2004). Diseases introduced by non-native species can stress native populations that have no natural resistance to the new disease (NPS 1997). Another risk associated with non-native species is hybridization with native species (Huxel 1998) which changes the genetics of the native population (NPS 1997). In northern California an invasive cordgrass, *Spartina alterniflora* hybridized with the native *Spartina foliosa* creating a more robust hybrid species which now threatens to change the ecology of the San Francisco Bay's costal wetlands (Daehler and Strong 1997). Hybridization poses risks not only at the organismal level (direct competition for habitat, food, or mates) but also at the genetic level, such as outbreeding depression (Rhymer and Simberloff 1996). With the increasing popularity of genetically modified food species and the high degree of human mobility, understanding biotic invasions will only increase in importance.

Many areas of the planet have already been invaded. Invasive species are found in terrestrial (D'Antonio and Meyerson 2002), marine (Bax, Williamson et al. 2003), estuarine (Moyle 1986), and freshwater habitats (Moyle and Light 1996). *Tamarix spp.* (salt cedar) has established itself successfully outside its natural range (D'Antonio and Meyerson 2002). Another terrestrial invader, *Bufo marinus*, the cane toad, was brought to northeast Queensland, Australia as early as 1935 to control agricultural insect pests (Mungomery 1935). The cane toad's rapid territorial expansion has prompted the recommendation that vulnerable taxa be relocated to toad-inaccessible islands (Phillips, Brown et al. 2007). The waters off of Hawaii support introduced populations of several species of herring, snapper and grouper (Maciolek 1984). In addition, introduced populations of chameleon goby (*Tridentiger trigonocephalus*) and yellowfin goby (*Acanthogobius flavimanus*) have been established in the Pacific Ocean (Moyle 1986). Especially in the marine environment, invasive species may alter the new environment in ways beneficial to the invading species (D'Antonio and Meyerson 2002; Bax, Williamson et al. 2003). Introduced species such as stripped bass are common in western estuaries although their impact on the habitat and native community varies (Moyle 1986). In the western United States striped bass are the most common introduced species in estuaries (Moyle 1986). In freshwater environments invasive species have had some disastrous effects. The Great Lakes ecosystems have been changed by the introduction of the rainbow smelt (*Osmerus mordax*), the alewife (*Alosa pseudoharengus*) the sea lamprey (*Petromyzon marinus*) (Moyle 1986), and in 1986 the zebra mussel (*Dreissena polymorpha*) (MacIsaac 1996). However, it is also true that in some freshwater systems invasive species have become established without drastic consequences (Moyle and Light 1996). Even in the case of the zebra mussel there are data that the impacted species of bivalves were in decline before the introduction of the zebra mussel (Gurevitch and Padilla 2004). Not all of the 50,000 non-indigenous species in the United States (Pimentel, Lach et al. 2000) are harmful.

Although invasive species are present in many habitats, some habitats remain free of invasive species (Mooney and Cleland 2001; D'Antonio and Meyerson 2002). In one model of the invasion process there are four stages a species must pass through in order to become invasive (Lockwood, Hoopes et al. 2007). These four stages are transport, establishment, spread and impact. At each stage there is a possibility of success or failure. For example, during the transport stage, introduction is considered a success and death is considered a failure. The differing rate of invasion can come from differences in magnitude of spread of the invading organism (Byers, Reichard et al. 2001; Sakai, Allendorf et al. 2001), propagule pressure (the combined force of number and density of reproductive individuals and the frequency and duration of introduction), adaptability of the invading organism, or the invasibility of the ecosystem being invaded (Sakai, Allendorf et al. 2001). Some have suggested high biodiversity is linked to low invasibility but this is open to debate (Miller, Kneitel et al. 2002). Moyle (1986) found several commonalities among fish taxa that predicted invasion success; (1) the species is hardy and can survive transport and disturbed environments, (2) the species is aggressive in predation and competition, (3) the species is behaviorally or ecologically distinct from the native species which are unable to adapt to new styles of predation and competition, (4) the species has an unusually robust reproductive strategy, (5) the species is preadapted to local conditions, (6) the species is a good disperser, or any combination of the above.

Many factors influence an invasive species' success in its new habitat. Lack of natural predators (Pimentel, Lach et al. 2000), ability to be an effective predator (Pimentel, Lach et al. 2000), presence of artificial or disturbed habitat (Pimentel, Lach et al. 2000; D'Antonio and Meyerson 2002; Bax, Williamson et al. 2003), and high adaptability to the new environment (Pimentel, Lach et al. 2000) are a few of those factors. Moyle and Light (Moyle and Light 1996) argue that the best predictor of an invasive species successfully invading an area is the presence of suitable abiotic factors for the invasive. Moyle and Light (1996b) also predict that areas with high levels of human disturbance will be more easily invaded by a larger number of exotics.

Extirpation is a real threat for turtles in areas impacted by humans. A twenty-year study found recreation on wood turtle (*Clemmys insculpta*) habitat caused its extirpation (Garber and Burger 1995). Several reptile and amphibian species have been extirpated in the state of Pennsylvania. Examples include the eastern tiger salamander (*Ambystoma tigrinum tigrinum*), the eastern mud salamander (*Pseudotriton montanus montanus*) and the midland smooth softshell (*Trionyx muticus muticus*) (McCoy 1985). Although McCoy (1985) also lists Blanding's turtle (*Emydoidea blandingii*) as extirpated from Pennsylvania, the Pennsylvania Fish and Boat Commission currently lists Blanding's turtle as a candidate species (Pennsylvania 2005). While not extirpated from Pennsylvania, the red-bellied turtle has been extirpated from much of its natural range.

Invasive organisms have the potential to compete for food with native species while simultaneously changing the species composition of the area. For example, both the native and introduced fish species in the Suisun marsh (northern California) feast on the opossum shrimp (*Neomysis mercedis*) when its numbers increase in the summer (Moyle 1986). As the numbers of opossum shrimp decrease in the fall the native species switch to other prey items while the introduced species continue to eat the opossum shrimp (Moyle 1986).

The outcome of competition between a native and an invasive species is not a foregone conclusion. In an Illinois study the slider turtle, *Trachemys scripta* outnumbers the painted turtle, *Chrysemys picta* by a wide margin (Dreslik, Kuhns et al. 2005). Dreslik et al. (2005) also note that in northern Illinois assemblages painted turtles outnumber slider turtles, while in the south, slider turtles outnumber painted turtles.

Wetland losses and fragmentation present an additional stress on native aquatic species. By the 1980's the forty-eight contiguous states of the United States lost 53% of the wetlands present in the 1780's (Dahl 1990). Fragmentation and loss of wetlands may have a stronger effect than the presence of invasive species on the survival and abundance of native wetland species.

Turtles are prominent members of the wetland community. In the Eastern United States the red-eared slider turtle has been recognized as an invasive because of extra-limital established breeding populations (Ernst et. al. 1994, Moll and Moll 2004). The red-eared slider turtle may be affecting the abundance and distribution of other turtles. Therefore, it may provide a good model system to study effect of an invasive species on closely related taxa.

Invasion of the red-eared slider turtle

A well-known vertebrate species that has invaded and become established outside its natural range is the slider turtle. The red-eared slider turtle *Trachemys scripta elegans*, is a subspecies of *scripta* that has long been sold in pet stores in the United States. It has an eye catching red post-orbital stripe, which may contribute to its popularity as a pet. The natural range of the slider turtle (Figure 1) encompasses much of the southeastern United States and continues south into Mexico (Ernst 1990; Ernst, Lovich et al. 1994; Seidel 2002). *Trachemys scripta* includes several subspecies with slightly different native ranges. *Trachemys scripta elegans* has a natural range from Southwest Michigan to the Gulf of Mexico along the Mississippi Valley (Ernst 1990; Seidel 2002). *Trachemys scripta scripta* has a yellow post orbital blotch and a native range from southeastern Virginia to northern Florida (Ernst 1990; Seidel 2002). *Trachemys scripta trootsii* has a narrow yellow post-orbital stripe and a native range of southeastern Kentucky to northeastern Alabama in the upper portions of the Cumberland and Tennessee Rivers (Ernst 1990; Seidel 2002). There are at least ten other subspecies that occur to the west and south of the areas mentioned above (Ernst 1990). However, Seidel (2002) proposes a revision of the *Trachemys* taxonomy based on phylogenetic analysis. Seidel's revision increases the number of species of slider turtle (Figure 1) but the ranges are similar to Ernst (1990).

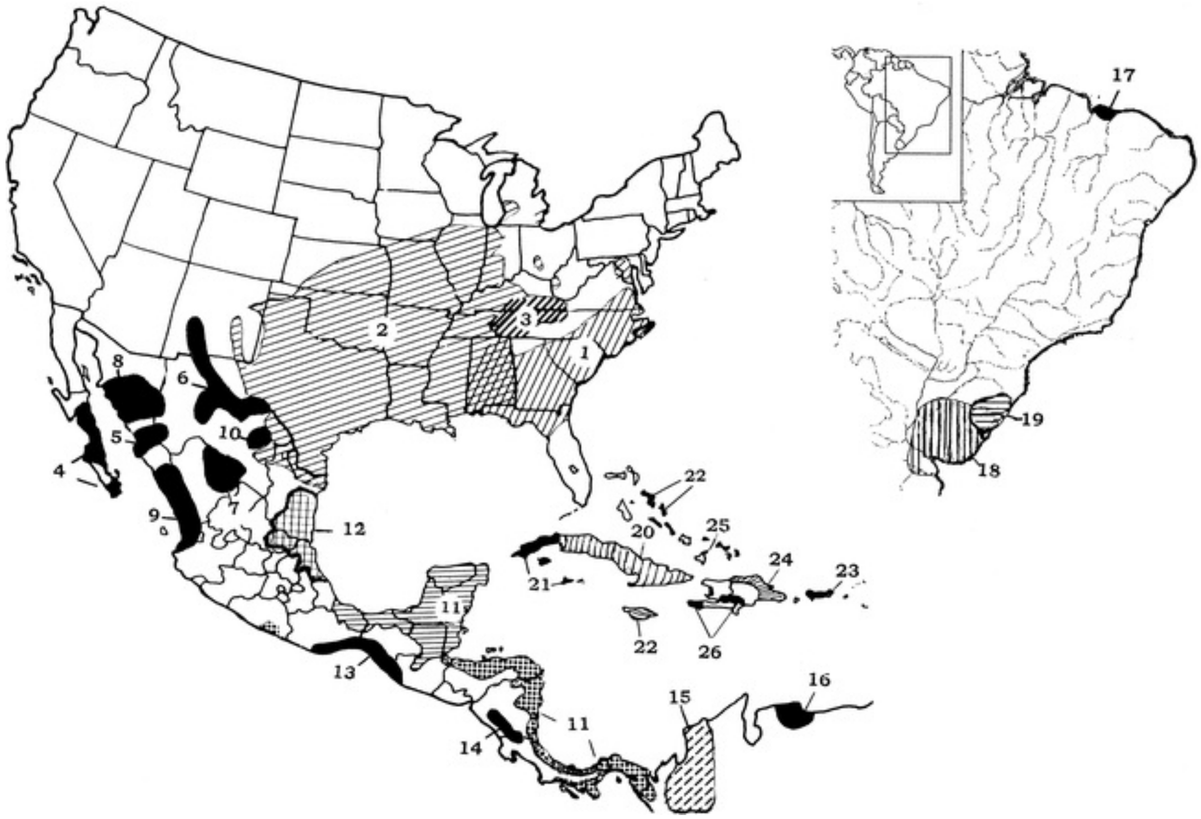

Figure 1: Extant species and subspecies of *Trachemys* in the United States (Seidel 2002) 1: *T. s. scripta*, 2: *T. s. elegans,* 3: *T. s. troostii,* 4: *T. nebulosa nebulosa*, 5: *T. n. hiltoni*, 6: *T. gaigeae gaigeae,* 7: *T. g. hartwegi*, 8: *T. yaquia*, 9: *T. ornate*, 10: *T. taylori*, 11: *T. venusta venusta*, 12: *T. v. cataspila*, 13: *T.v. grayi*, 14: *T. emolli*, 15: *T. callitostris callirostris*, 16: *T. c. chichiriviche*, 17: *T. adiutrix*, 18: *T. dorbingni dorbigni*, 19: *T. d. brasiliensis,* 20: *T. decussata decussata,* 21: *T. d. angusta*, 22: *T. terrapen*, 23: *T. stejnegeri stejnegeri*, 24: *T. s. vicina*, 25: *T. s. malonei,* 26: *T. decorata*.

Since the red-eared slider turtle is commonly sold in pet stores it has a transport mechanism in place. This may give the red-eared slider turtle an advantage in Lockwood's (2007) transport stage of invasion or Colautti and MacIsaac's transport vector survival and release filter (between stage I and II) (Colautti and MacIsaac 2004) and consequently it may be a more common invader than other subspecies.

Red-eared slider turtles were at one point the most popular pet turtle sold in the United States (Ernst 1990). The pet trade has facilitated the introduction of the red-eared slider turtle around the world (Ernst, Lovich et al. 1994). In the period from 1985 to 1994 France alone imported 4,238,809 turtles (Warwick 1991). In 1996 8.4 million red-eared slider turtles were exported or re-exported from the United States (Hoover 2000). There were 52,122,389 red-eared slider turtles exported from the United States between 1989 and 1997 (Telecky 2001). In that same period 5,252,173 red-eared sliders were imported by the US (Telecky 2001). In 1997 red-eared slider turtles were a top reptile export from the US (Telecky 2001). The red-eared slider turtle was also one of the top turtle species imported by the United States in 1997, however the number of lizard imports was much larger than the number of turtle imports (Telecky 2001). This is an improvement from 1970, before the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), when just under 80% of the 2 million reptiles imported by the US annually were red-eared sliders (Hoover 2000).

In the United States the red-eared slider turtle has been documented reproducing outside of its native range in southeastern Pennsylvania (Avery, Spotila et al. 2006), Washington D. C. (Ernst 1990), New Jersey (Stein, Eames et al. 1980), Michigan (Edgren 1943), south Florida (Wilson and Porras 1983; Hutchison 1992), Maryland (Ernst, Lovich et al. 1994), Arizona (Hulse 1980) and South Carolina's Atlantic barrier islands (Ernst, Lovich et al. 1994).

Red-eared slider turtles have been documented in many countries outside of their natural range such as Japan (Ernst 1990), South Korea (Platt and Fontenot 1992), Thailand, Germany (Ernst, Lovich et al. 1994), France, South Africa, Israel, the West Indies (Schwartz and Henderson 1991), Great Brittan (Ernst 1990) and Australia (Ernst, Lovich et al. 1994). The red-eared slider turtle has been found on many islands in the south pacific such as; Saipan (Rodda, Fritts et al. 1991), Pohnpei, Hawaii (Buden, Lynch et al. 2001) and documented reproducing in the south of France (Cadi, Delmas et al. 2003) and on Guam (Rodda, Fritts et al. 1991).

The slider turtle fits many of Moyle's commonalities of invasive taxa: a symbiotic relationship with humans (for example as food, pets or agents of biological control), a history of successful invasion (Maciolek 1984; Hutchison 1992; Platt and Fontenot 1992; Cadi, Delmas et al. 2003; Moll and Moll 2004; Ramsay, Ng et al. 2007), large native range(Ernst, Lovich et al. 1994), wide range of physiological tolerances and a match between the invasive species' native habitat and the habitat being invaded (Moyle and Marchetti 2006). The red-eared slider is hardy enough to survive transport (shown by sale of live individuals shipped between countries, (Telecky 2001) and to be viable in degraded environments (Bodie, Semlitsch et al. 2000).

The success of the slider turtle as an invader may be due to the slider turtles' aggressive competition for basking sites and mates (Moyle 1986; Cadi and Joly 2004) and generalist habitat and diet requirements (Moyle 1986; Parmenter and Avery 1990). Cadi and Joly (2004) showed the slider turtle to be a superior competitor for basking sites to the

European Pond Turtle, *Emys orbicularis.* The smaller size of *E. orbicularis* compared to *T. scripta* may contribute to differences in basking site occupation and interference mating.

The red-eared slider turtle is an omnivore although older individuals eat a primarily herbivorous diet (Parmenter and Avery 1990). *Trachemys scripta* eat more when the water they live in is warmer (Avery, Spotila et al. 1993). As the protein content of their diet increases and the ambient water temperature is warm (34°C), *T. scripta* are able to digest their food more quickly. A temperature of 34°C also allows *T. scripta* to assimilate food with a digestive efficiency of over 95% (Avery, Spotila et al. 1993). For comparison, *Pseudemys nelsoni* (the Florida red-bellied turtle – a relative of *Pseudemys rubriventris*) foraging on *Hydrilla verticillata,* a plant with high fiber content, achieved a digestive efficiency of only 80%-83% (Bjorndal and Bolten 1990). *Pseudemys nelsoni* have microbial symbionts in the gut which allow this high rate of digestive efficiency while eating high fiber foods, like *Hydrilla* (Bjorndal and Bolten 1990). *Trachemys scripta* have a lower digestive efficiency when primarily herbivorous than do *P. nelsoni* (Bouchard and Bjorndal 2005). However, a juvenile *T. scripta* foraging in warm summer waters rich in protein sources would be able to quickly find and process high quality food, allowing it to grow faster than other strictly herbivorous species.

The red-eared slider turtle has similar life-history traits and habitat requirements to the red-bellied turtle, *Pseudemys rubriventris* (Ernst, Lovich et al. 1994) that is native to Pennsylvania and listed as a threatened species (PA Game Commission). Therefore, we expect that the species would compete for resources and existence of the red-eared slider turtle would come at the expense of the red-bellied turtle.

The threatened red-bellied turtle in Pennsylvania

The red-bellied turtle had a continuous distribution on the east coast of the United States from Virginia to New England (Waters 1962). The formerly emergent continental shelf (2,000 to 3,000 years ago) facilitated movement between the current populations (Waters 1962). In the 1800's the red-bellied turtle experienced a population decline and extirpation in New York state due to harvesting (Hulse, McCoy et al. 2001). The small allozymic differences between the population in Massachusetts and the contiguous population further south (Figure 2) indicate that the separation of the two populations happened recently (Browne, Haskell et al. 1996). The Massachusetts population was protected as an endangered species when it was considered a distinct species from other red-bellied turtle populations. The Massachusetts population, whether a separate subspecies or not, is nowhere abundant (Graham 1971).

As early as 1978 the red-bellied turtle has appeared on Pennsylvania Fish Commission lists of endangered amphibians and reptiles (McCoy 1985). By 1985 the red-bellied turtle was known to exist in Pennsylvania only in isolated colonies in a few counties (Figure 3) (McCoy 1985). Small (less than thirty individuals) colonies were known in Manor and Silver lakes in Bucks county, the Tinicum wetlands in Philadelphia and Delaware counties, the West Branch of Conococheague Creek in Franklin County and possibly Springton Reservoir in Delaware county (McCoy 1985). *Pseudemys rubriventris* have been seen in the Pocconos in Pennsylvania, although they are likely to be outside of their natural range (Bien, personal communication). See Appendix A and Appendix B for a list of other sites in southeastern Pennsylvania where the presence of red-bellied turtles has been documented.

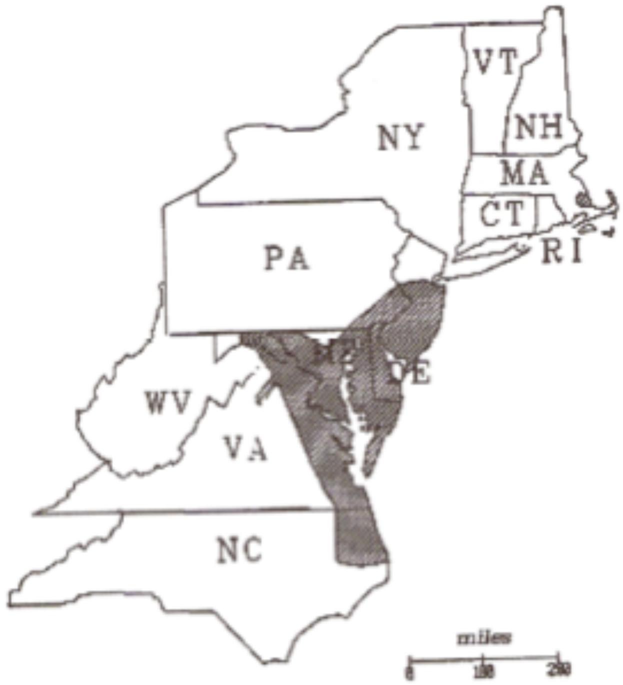

Figure 2: Known range (as of 1994) of the red-bellied turtle, *Pseudemys rubriventris* (Ernst et. al., 1994)

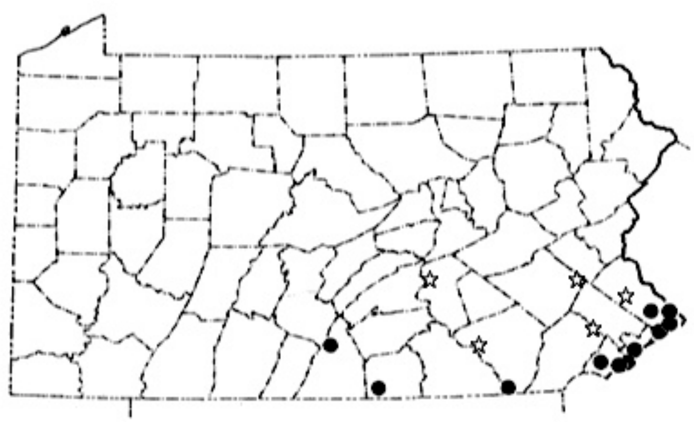

Figure 3: Locations where red-bellied turtles have been documented before 1985 in Pennsylvania (McCoy, 1985) indicated by filled circles. Counties with documented occurrence of red-bellied turtles before 1985: Adams, Bucks, Delaware, Franklin, Lancaster and Philadelphia. Since 1985 red-bellied turtles have also been documented in the following counties: Berks, Chester, Montgomery, Perry and York - indicated by stars.

The potential threats to red-bellied turtle populations are numerous. For example: wetland loss, habitat fragmentation, pollution, collecting of turtles for pets, food or other trophies, competition with the invasive red-eared slider turtle for food, habitat, basking sites or nesting sites, and the potential for hybridization with red-eared slider turtles.

Native turtle communities in southeastern Pennsylvania.

Painted turtles, *Chrysemys picta picta* (Eastern painted turtle, abundant) and *Chrysemys picta marginata* (Midland painted turtle, abundant), and snapping turtles (*Chelydra serpentina,* abundant), make up a large portion of the turtle community in many wetlands in Southeastern Pennsylvania (Austen 2006). Other native turtle species that may occur include: the stink pot (*Sternotherous odoratus,* abundant), the Eastern mud turtle (*Kinosternum subrubrum subrubrum,* extirpated), the map turtle (*Graptemys geographica,* species of special concern), Eastern spiny soft shell turtles (*Apalone spinifera spinifera,* species of special concern), midland smooth softshell (*Apalone mutica mutica,* extirpated), spotted turtle (*Clemmys guttata,* species of special concern), Blanding's turtle (*Emys blandingii*), wood turtles (*Gleptemys insculpta,* species of special concern), and Red-bellied turtles (*Pseudemys rubriventris,* threatened) (Austen 2006).

Therefore there are many potential impacts of red-eared slider turtles on red-bellied turtles. However, there are few studies that have quantitatively assessed the interactions between these species. As a first step in such assessment I sought to quantify the distribution and abundance of the two turtle species in Southeastern Pennsylvania.

Chapter 2: Objective and Specific Aims

Objective

The objective of this study was to determine the current range and abundance of red-bellied turtles and red-eared slider turtles in southeastern Pennsylvania and to determine the impact of human-originated development on the two species.

Specific Aims

1. Determine the current range of the red-bellied turtle (Pseudemys rubriventris) and the red-eared slider turtle (*Trachemys scripta*) in Southeastern Pennsylvania.
2. Determine the relative and absolute abundances of red-eared slider turtles and red-bellied turtles in selected wetlands. Determine whether relative abundance estimates differ between visual observation and trapping/marking of individual turtles.
3. Determine stage class structure of turtle populations for each wetland trapped.
4. Determine whether human accessibility, or the ease with which humans can enter a wetland, is related to the occurrence and abundance of red-eared slider turtles and red-bellied turtles in that wetland.
5. Determine whether development of adjacent upland habitat to wetlands is related to the occurrence and abundance of red-eared slider turtles and red-bellied turtles in that wetland.

Materials and Methods

I recorded the occurrence of red-bellied turtles and red-eared slider turtles at sites where red-bellied turtles were documented to occur historically. Basking turtles were identified using binoculars (Aerolite model No. 734, 7x .35 mm) and a spotting scope (Searcher model No. 839, 40x and 20x .66mm) with tripod. I determined the species and approximate size class (hatchling, juvenile, adult). I also recorded information about the available habitat and the types of development for each site. I captured turtles in Darby Creek at John Heinz National Wildlife Refuge (JHNWR) in 2007 and at Silver Lake Nature Center (SLNC) in Bucks County and Fort Mifflin in Philadelphia County in 2008 and 2009 with baited hoop net traps and basking traps.

Basking turtle observations

The field team for basking observations consisted of six trained observers who made the majority of the observation visits. Other expert observers helped with training and occasionally made observation visits. On a typical day each two-person team visited between four and seven sites, depending on distance between sites. Each visit to a wetland to look for turtles was made at a time when we were likely to successfully observe basking turtles. During the early and late parts of the season field teams made observation visits in the middle, warmer part of the day (between 10:00 and 14:00) (Ernst, Lovich et al. 1994). During the middle of the season, the field teams made visits at the beginning or end of the day (between 7:00 and 12:00 or between 17:00 and dusk) (Ernst, Lovich et al. 1994). Observations were made only on sunny days, however, the occasional cloud or brief rain shower did not always cause the turtles to interrupt their basking. Therefore we did not abandon surveying for occasional clouds and brief rain showers. The timing of observations increased the opportunities for the observers to encounter basking turtles.

Field teams visited 52 sites in Southeastern Pennsylvania where red-bellied turtles have been documented. For a list of sites please see appendices. We visited most sites four or more times in 2006. One site (Route 76) was visited three times because it was determined that the wetland was not suitable habitat for red-bellied turtles or red-eared slider turtles. The marshland north of the turnpike was on the list as the probable origin of a turtle found injured on the side of the road in 2002. In 2006 we could not find suitable habitat. Monocacy Battlefield and the mouth of the Schuylkill were also determined not to be suitable habitat and were visited once and twice respectively. At the mouth of the Schuylkill site a shipping company (VANE) allowed us onto their dock to look for turtles. Multiple visits to John Heinz NWR were conducted in 2007, concurrent with trapping. In 2009 multiple visits to both Silver Lake sites, Magnolia Lake and Fort Mifflin were conducted, also concurrent with trapping.

At each site, we recorded air temperature and average wind speed using a Kestrel Weather Meter. We recorded habitat data at each site: we noted whether the wetland was a lake, pond, stream, marsh, or river; we took note of shoreline development such as the presence of dirt or paved roads (and their distance from the wetland), dams, bridges, houses, camps, industrial buildings, trains, trails and whether the wetland was in a public park; we recorded the number and type of potential and used basking objects. We recorded the type of vegetation present in four levels of the wetland: the upland area, the edge of the wetland, the emergent vegetation area and the aquatic area. See Appendix C for a sample data sheet.

I developed a ranking system based on several variables we collected at each wetland. I assigned one point each for a "yes" to shoreline development, dirt road, bridge, industry, trail, or train tracks. If part or all of the wetland was visible from the road, I also assigned one point. I assigned two points each to paved road, camp, house, people at the site, direct vehicle access, or public park. If the distance to either type of road is less than 0.3 km I added an additional point. Each wetland's point score determines its rank. Higher points indicate higher wetland degradation or anthropogenic influence. All wetlands had a road less than 0.3 km from the edge.

Observational data methods

I calculated density and relative abundance of each species at each wetland from the observational data and from the mark-recapture data. Relative abundance was calculated by three different methods, each represented in the literature: dividing the number of individuals in one species of turtle by the total number of individuals of all turtle species, dividing the number of individual *P. rubriventris* by the number of individual *T. scripta*, and dividing the number of individuals of a species by the surface area of the wetland. Estimates of relative abundance of each species and by each method were compared. When calculating the ratio of *P. rubriventris* to *T. scripta* I replaced zeros with 0.1. Although we did not see turtles it is possible that there is a turtle in that wetland.

I measured the distance between each wetland and the nearest walking path and the distance between each wetland and the nearest paved road using ArcView. A second measure of accessibility was whether or not the wetland was in a public park. I analyzed the data to determine whether a relationship exists between accessibility and stage structure or between accessibility and relative density.

I measured the surface area of each wetland using both ArcView and Acme Laboratories' Google Planimeter (http://www.acme.com/planimeter). I measured the wetlands in ArcView using the base software and calculated the area from a measured length and a measured width on screen. The measurements from the Planimeter were computed by the program after I indicated the edges of the wetland. For wetlands like rivers where we were observing turtles at a specific point on the river, but not over the whole length of the river, the approximate surface area in view of the investigator was calculated.

I calculated the average number of turtles of each species. I divided the total number of turtles observed at each site by the number of visits to that site. I also compared the ratio of *P. rubriventris* to *T. scripta* observed and trapped at three sites: JHNWR, Fort Mifflin and Silver Lake Nature Center. Two sets of abundance estimates were generated for wetlands with multiple visits. One set included relative abundances based on individual site visits. The other set included relative abundances based on every turtle sited at a particular site divided by the number of visits to that site where at least one turtle was spotted. I calculated the density by dividing the number of individuals of a species by the surface area of the wetland. Data analysis was done in PASW 17 and 18 and in R using the packages Vegan, Biodiversity R, as well as the standard packages.

I used the basking data to determine the existence of a relationship between development of adjacent upland habitat and stage structure of each species or relative species density.

In order to compare the efficacy of the two methods (observation of basking turtles and intensive trapping) I calculated effort in assessing the distribution and abundance of turtles for each method. For the observation method, a visit was considered a unit of effort.

According to state guidelines four visits (or units of effort) would be required to adequately sample an area. Results were reported in terms of observations per visit. The shortest visit was 4 minutes and the longest was 240 minutes. The mean visit length was 27.45 minutes (standard error: 1.89). The median visit length was 22 minutes. Only 166 of 183 visits had both arrival time and departure time, so more than half of the visits were included in the effort calculation.

A paired t-test was used to control for differences between wetlands. Using the paired t-test insures that the number of *P. rubriventris* at a particular wetland was compared to the number of *T. scripta* at that same wetland.

To determine if four visits were sufficient to detect turtles at a wetland. I used a binary logistic regression on the number of visits it took to detect any turtle, red-eared slider turtles, red-bellied turtles, and both red-eared slider turtles and red-bellied turtles. From the regression I obtained a coefficient and an intercept (B) from the binary logistic regression function in PASW17 and used the equations:

$$\ln\left(\frac{p}{p-1}\right) = B_1 + -1.262(V_1)$$

$$\ln\left(\frac{p}{p-1}\right) = B_2 + -0.804(V_2)$$

$$\ln\left(\frac{p}{p-1}\right) = B_3 + -2.696(V_3)$$

$$\ln\left(\frac{p}{p-1}\right) = B_4 + -0.906(V_4)$$

B_1= 4.160, V_1=Number of visits required to detect any turtle or total number of visits to a site if no turtle was detected. B_2= 2.309, V_2= Number of visits required to detect a red-eared slider turtle or total number of visits to a site if no turtle was detected. B_3=5.494, V_3= Number of visits required to detect a red-bellied turtle or total number of visits to a site if no turtle was detected. B_4=2.002, V_4= number of visits required to detect both turtle species or total number of visits to a site if no turtle was detected.

I used the log odds to show the relationship between the number of visits and the probability of detection. I converted log-odds back to probability for Figure 15 by first taking the inverse of ln (p/(p-1)) and then using the equation

$$p = (\frac{p}{p-1})/1 + (\frac{p}{p-1})$$

Trapping methods

In 2007 we trapped intensively at one site, Darby Creek in John Heinz National Wildlife Refuge. In 2008 and 2009 we trapped intensively at Silver Lake, Magnolia Lake, and Fort Mifflin. We trapped turtles using baited hoop net traps (corn, sardines and mixed vegetables), basking traps, and opportune hand captures. For the methods comparison I used only days where we trapped and did observations. For comparison of effort with other trapping studies I used trap-hours.

Each captured turtle's species, sex, reproductive state (i.e., gravid or not), health status (e.g., lethargic, presence of *aeromonas*), injuries (e.g., injuries to limbs, shell, head, etc.), apparent developmental defects and estimated age were recorded. Straight plastron length, straight carapace length, straight carapace width, carapace height, body mass, and GPS location of capture were measured and recorded. All captured turtles were marked with codes consistent with previous mark recapture studies in the area e.g. Avery et. al. (2006). Turtles were promptly released close to their capture location, with the exclusion of *T. scripta* in 2007 and 2009. In 2008 we had special permission from the Pennsylvania Fish and Boat Commission to re-release the red-eared sliders in order to get an accurate population estimate.

At John Heinz National Wildlife Refuge the traps were set and checked daily due to the tidal flux of Darby Creek. Traps were checked and set daily at times determined by the tides. Since the change in depth in Darby creek (John Heinz NWR) with tides was over 1 meter due to the tides, we set traps each day about an hour after high tide and pulled them each day about an hour before the next high tide. This meant that our traps were not in the water more than six hours at a time, but that we did not drown any turtles.

At Silver Lake Nature Center and Fort Mifflin, we set traps on Mondays, checked traps in the mornings Tuesday through Friday, and pulled them on Fridays. All fieldwork was conducted at sites within and near the edge of the range of the red-bellied turtle based on historic records and observational data collected to date (i.e., 2005 - 2007 field seasons).

Trapping data methods

Size classes were determined using published accounts from the literature (Avery, Spotila et al. 2006). Red-bellied turtle size class determination followed Graham (Graham 1971); Hatchling, ≤75 mm plastron length; Sub adult, 76 mm – 175 mm; and Adult, ≥ 176 mm plastron length. For red-eared sliders I followed Cagle (Cagle 1946), Gibbons and Lovich (Gibbons and Lovich 1990) and Gibbons, et. al. (Gibbons, Semlitsch et al. 1981); Hatchling, ≤ 50 mm plastron length; Sub adult, 51 mm – 100 mm; and Adult, ≥ 101 mm plastron length. Painted turtle size classes followed St. Clair, et. al. (St. Clair, Gregory et al. 1994); Iverson and Smith (Iverson and Smith 1993); Ernst (Ernst 1971); Hatchling, ≤ 40 mm plastron length; Sub adult, 41 mm – 80 mm; and Adult, ≥ 81 mm plastron length.

Trapping effort was calculated for each site. At John Heinz National Wildlife Refuge in 2007 we used 10 traps. Traps were in the water for approximately 4 hours each day for 23 days. 920 trap-hours means 38 trap-days after correcting for the short amount of time the traps were in the water each day. In 2006 at Silver Lake Nature Center six traps were set for

66 days and left in the water for the whole 24-hour period. The 2006 SLNC trapping period was 396 trap-days or 9,504 trap-hours. The 2008 SLNC trapping period was 25 traps over 50 days, or 1250 trap-days, or 30,000 trap-hours. The trapping period at Fort Mifflin in 2009 was 25 traps over 34 days, or 850 trap-days, or 20,400 trap-hours. The trapping period at Silver Lake Nature Center in 2009 was 25 traps over 25 days, or 625 trap-days, or 15,000 trap-hours.

Stage class distribution

One way to evaluate populations' vital rates (birth, death, emigration and immigration) is to analyze the distribution of body sizes of individuals in the population of interest. Body size structure of a population is analogous to age structure or stage structure. Previously unmarked turtles may be difficult to age reliably past five years, but by counting scute annuli, a young turtle's age may be determined (Cagle 1946). The size of captured turtles can be measured directly. The stage (hatchling, juvenile, adult) can be determined accurately for captured turtles and may be determined with reasonable accuracy for observed turtles that are close enough for accurate species identification. The body size structure of the population can reveal the state of the population by giving insight into the reproduction and recruitment rates. For example, if there are no hatchlings and we are reasonably sure that this is not due to trapping location or trapping bias, this could indicate that there is no reproduction in the population and additional turtles are being released by humans. If there are no juveniles but there are turtles in other age classes this would indicate a problem in survival and recruitment of hatchlings.

Chapter 4: Results

I observed turtles with and without binoculars and a spotting scope. In general, I was able to identify *T. scripta*, *P. rubriventris* and *C. picta* and to distinguish other species. However, sometimes it was difficult to identify a turtle to species especially when it was far away or partially obscured by obstacles in the field of view. For example, at 27 wetlands there were some turtles that I could not identify. At 14 of these sites I previously observed *T. scripta* and *P. rubriventris*.

In most cases the number of site visits for observation of basking turtles was four. In the case of John Heinz National Wildlife Reserve, the number of observation visits was thirty. I was able to make observational visits on the same days that I made trapping visits in 2007. Monocacy Battlefield was only visited once because there was no wetland near the GPS coordinates where *P. rubriventris* was documented at the Monocacy site. The documentation of the presence of *P. rubriventris* occurred in 1987 by a scientist with the Carnegie Museum, which now holds the specimen. In 2005 the site was removed from the Pennsylvania Environmental Review presumably because the site no longer provided appropriate habitat.

Occurrence and relative abundance of Red-bellied turtles and Red-eared slider turtles

Pseudemys rubriventris were observed at half of the 52 sites that had historical, documented presence of the species. At 8 (16%) sites *P. rubriventris* were observed but *T. scripta* were not (Figure 4). *Trachemys scripta* were observed at 25 sites. At 7 sites (15%) *T. scripta* were observed but *P. rubriventris* were not (Figure 5).

The ratio of *P. rubriventris* to *T. scripta* was different from one for most wetlands. This indicated that there were different numbers of each species within each wetland. At Lake Nockamixon and the Susquehanna observation site (not Lower Susquehanna) I observed a one-to-one ratio of *Pseudemys rubriventris* to *Trachemys scripta*. At 8 sites I observed other species of turtles. At 6 of these 8 sites where other turtles were observed but neither *P. rubriventris* nor *T. scripta* were observed I observed other turtles that I was unable to identify.

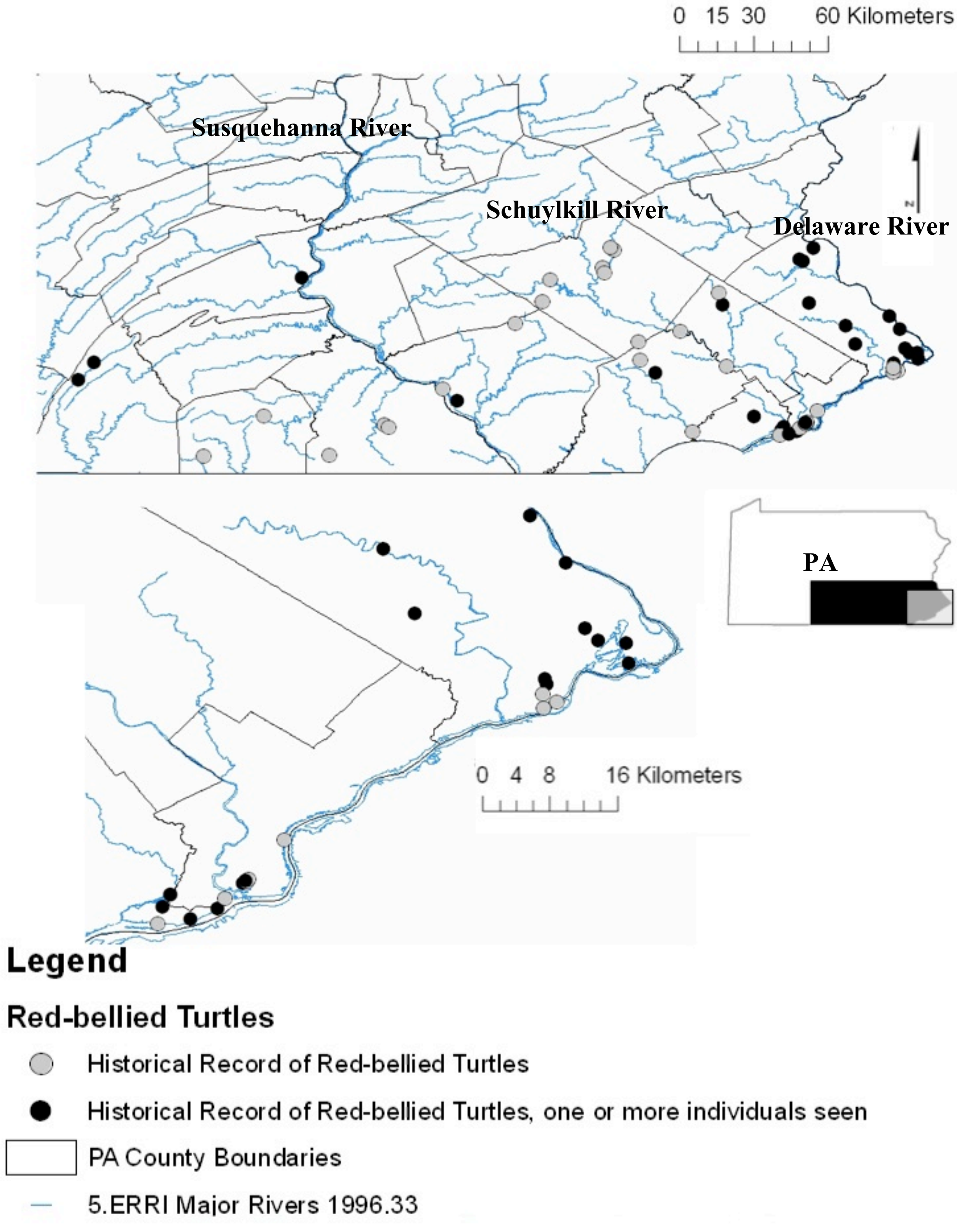

Figure 4: Survey results for *P. rubriventris.* Locations surveyed (all circles) are locations with a record of presence of *P. rubriventris.* Black circles indicate locations where *P. rubriventris* were observed in 2005 or 2006. Grey circles indicate no *P. rubriventris* were observed in 2005 or 2006.

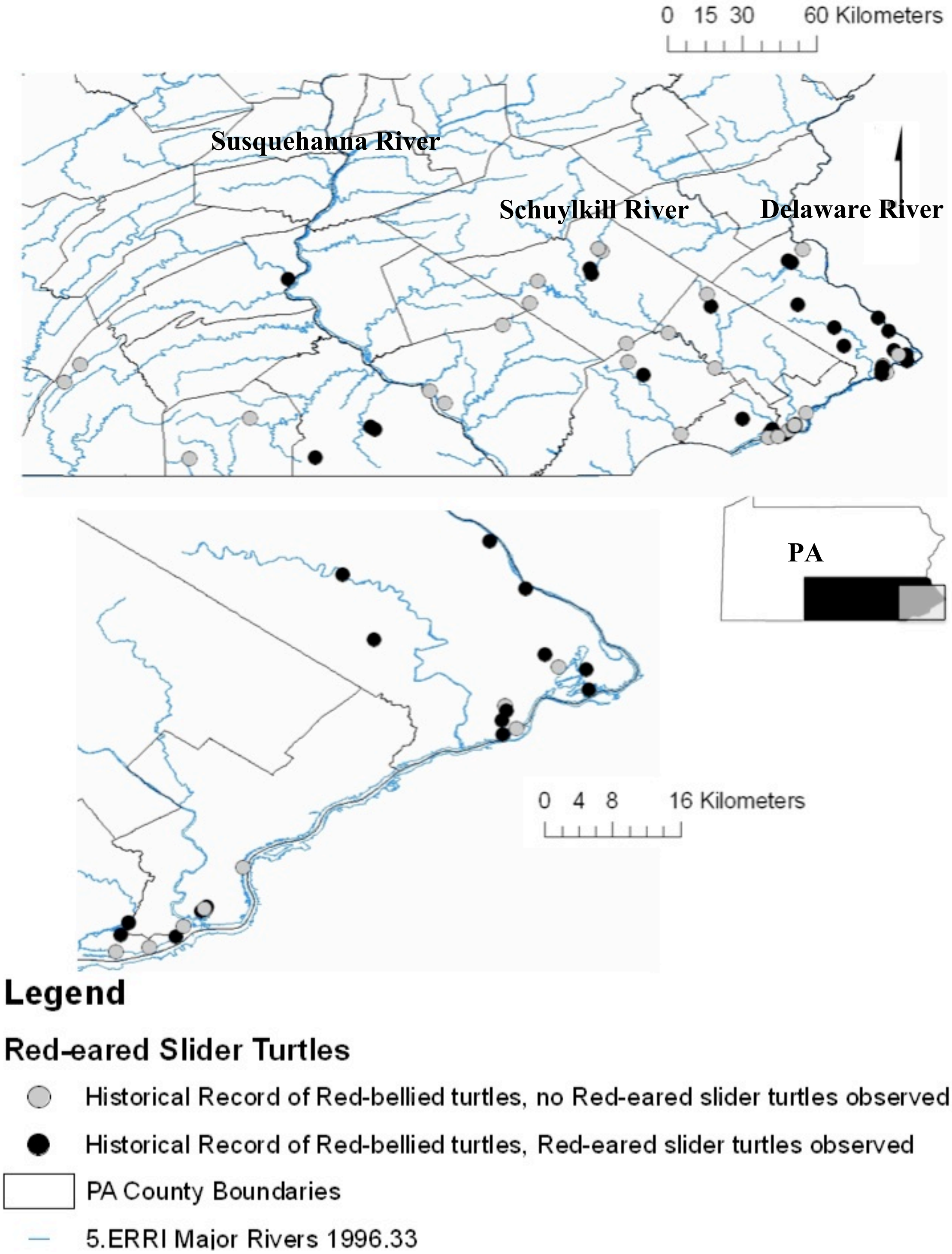

Figure 5: Survey results for *T. scripta.* Locations surveyed (all circles) are locations with a record of presence of *P. rubriventris.* Black circles indicate locations where *T. scripta* were observed in 2005 or 2006. Grey circles indicate no *T. scripta* were observed in 2005 or 2006.

There was no difference in presence-absence of red-eared slider turtles and red-bellied turtles at sites where red-bellied turtles, *P. rubriventris*, were documented historically based on a paired t-test (N = 238, t = -0.781).

No red-eared slider turtles were observed Lancaster and Franklin Counties, the only counties sampled in the Potomac Basin (stars in Figure 6). Counties where both species were present (diamonds in Figure 6), were almost all in the Delaware River Basin. In Perry County, although there were a few red-eared slider turtles, the ratio of red-bellied turtles to red-eared slider turtles was still high at 81:3. No red-bellied turtles were observed in York and Berks counties (circles in Figure 6). Very few turtles were observed at sites in York and Berks. (Table 1). The grouping of sites is based on Kruskal-Wallis pair-wise comparisons. Wetland pairs which are significantly different from each other follow. Adjusted Significance is in parentheses. Berks-Bucks (0.016), Berks-Delaware (0.05), Berks-Franklin (0.005), Berks-Perry (0.009), York-Franklin (0.025) and York-Perry (0.025).

Table 1: Red-bellied turtles to red-eared slider turtles in counties in Figure 6.

County	Red-bellied turtles : Red-eared slider turtles	Symbol in Figure 3
Lancaster	1:0	Star
Franklin	43:0	Star
Perry	83:1	Diamond
Delaware	26:4	Diamond
Chester	6:2	Diamond
Montgomery	4:5	Diamond
Philadelphia	35:48	Diamond
Bucks	68:135	Diamond
Berks	0:1	Circle
York	0:4	Circle
JHNWR (is the boundary between Delaware and Montgomery)	13:27	not in figure 3

Figure 6: Observed ratio of *P. rubriventris* to *T. scripta* by county. Blue stars indicate the counties with no red-eared slider turtles, blue diamonds indicate counties with both species and blue circles indicate counties with no red-bellied turtles. Observation data are overlaid on PA DEP map.

Negative relationship between human impact ranking of a wetland and relative abundance of red-bellied turtles.

I found more red-bellied turtles and fewer red-eared slider turtles in the least impacted wetlands (ranks 1 to 3) than I found in more impacted wetlands (ranks 4 to 12) (Figure 7). Painted turtles occurred in higher numbers in less disturbed wetlands than at more disturbed wetlands. Wetlands in ranks 1 to 3 had some commonalities such as: shoreline development, partial visibility from the road, and a paved or dirt road within 275m from the wetland edge.

At the moderately or highly impacted wetlands there were no red-bellied turtles. Wetlands of rank 4 to 12 also had some commonalities such as: paved roads within 275m of the wetland edge, location in a public park, visibility from the road, and houses visible from the wetland. Rank 6 does not appear in the figure. Red-eared slider turtles occurred in wetlands of all ranks 3 and above, with the exception of rank 6. In the most impacted wetland, painted turtles were the only species of turtle observed. In all visits to the four wetlands of rank 6, I observed only one turtle and was unable to identify the species. The most impacted wetlands (ranks 9 to 12) were surrounded by development or in industrial areas. Wetland edges were mowed or paved, there were cars and people at the site at every visit, trash was visible and there was a building at or near the edge of several of the wetlands.

The lowest ranked wetland had 5 points while the highest ranked wetlands had 17 points (Table 2). Points were assigned based on observed wetland characteristics as described in the methods section.

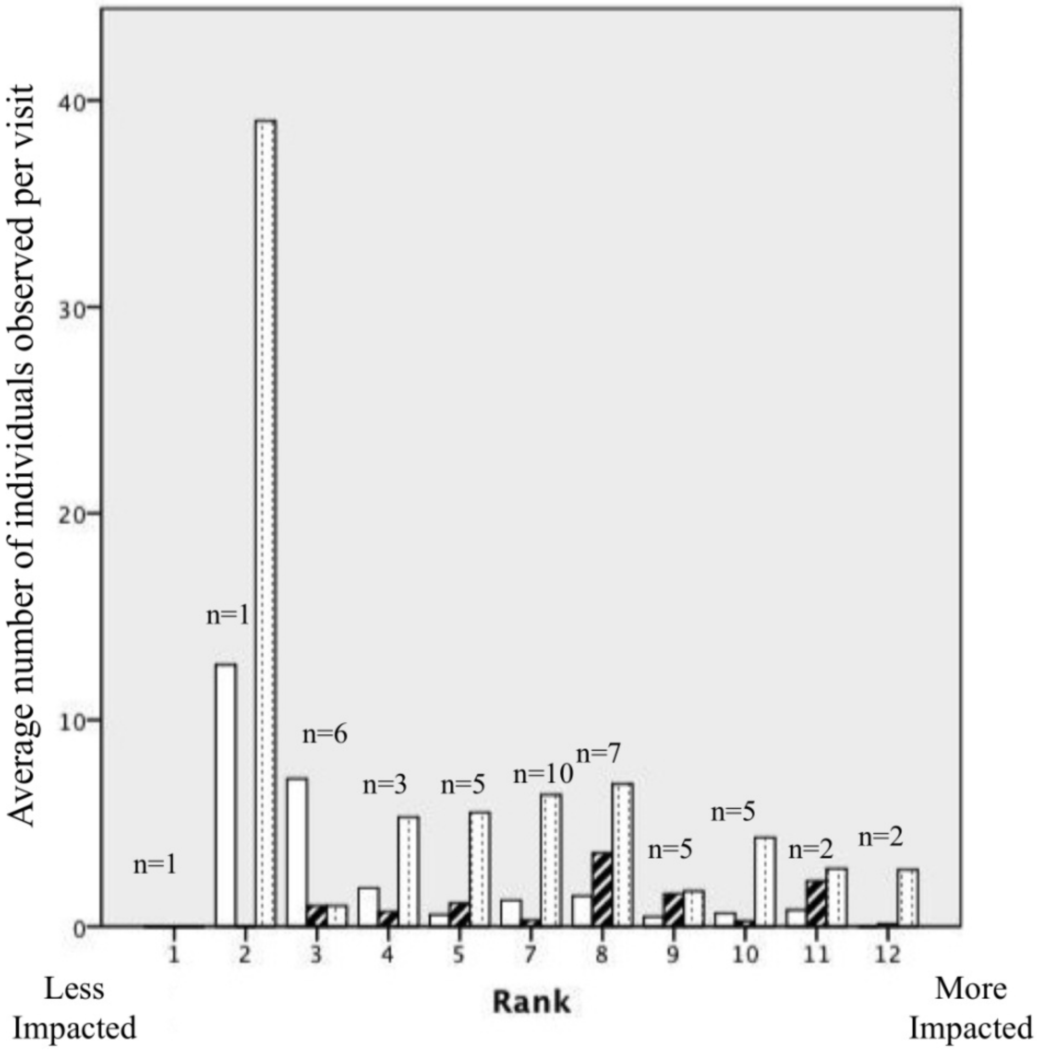

Figure 7: ***Pseudemys rubriventris*** **(white bars),** ***Trachemys scripta*** **(striped bars), and** ***Chrysemys picta*** **(dotted bars) at wetlands by rank where 1 is least impacted and 12 is most impacted. n = number of wetlands. No turtles were observed at the four wetlands of rank 6.**

Table 2: Ranks, points and numbers of wetlands at each rank. Points were assigned based on indicators of disturbance (See methods).

Rank	Points	Number of Wetlands at this rank	Names of Wetlands
1	5	1	Maiden Creek
2	6	1	Mountain Lake
3	7	6	Conewago Creek, Magnolia Lake, Redman Lake, Roosevelt Park – Lower Meadow Pond, Silver Lake South, Susquehanna River
4	8	3	Mountain Lake – Creek Road, Penn Warner, Pennsbury Manor
5	9	5	Juniata River, Maiden Creek – Christman Lake, Neshaminy Creek, Route 76, Wheat Sheaf Pond,
6	10	4	Green Lane Reservoir Upper, Lower Susquehanna River, Monocacy, Mouth of the Schulkill
7	11	10	Blue Marsh Lake, Car Wash Marsh, Darby Creek, Ontelaunee, Williams Lake, Manor School Pond, Middle Creek Lake, North of Hog Island Road, Rohm and Haas Ponds, Valley Forge Wetlands
8	12	7	Crum Creek Reservoir, Lake Galena, Lake Marburg, Nockamixon, Marsh Creek, Pottstown, Roosevelt Park – Edgewood
9	13	5	Churchville Reservoir, Delaware at Bristol, Little Tinicum Island, Roosevelt Park Creek, Silver Lake North
10	14	5	Chadds Ford, Fort Mifflin, Green Lane Reservoir Lower, Northkill, Roosevelt Park – Meadow Lake
11	15	2	Delaware at Philadelphia, Washington Crossing
12	17	2	Hopewell Lake, Lake Warren

The ratio of red-bellied turtles to red-eared slider turtles was highest in the least impacted wetlands (Figure 8). The Pearson's product-moment correlation between the rank of the site and the ratio of the number of *P. rubriventris* to *T. scripta* observed at a wetland was -0.275 ($p = 0.000$). These data showed that wetlands with more indicators of development had a significantly lower ratio of *P. rubriventris* to *T. scripta*. The correlation for observed *P.*

rubriventris and rank was 0.317 (p = 0.000). At more developed wetlands I observed fewer *P. rubriventris* per visit.

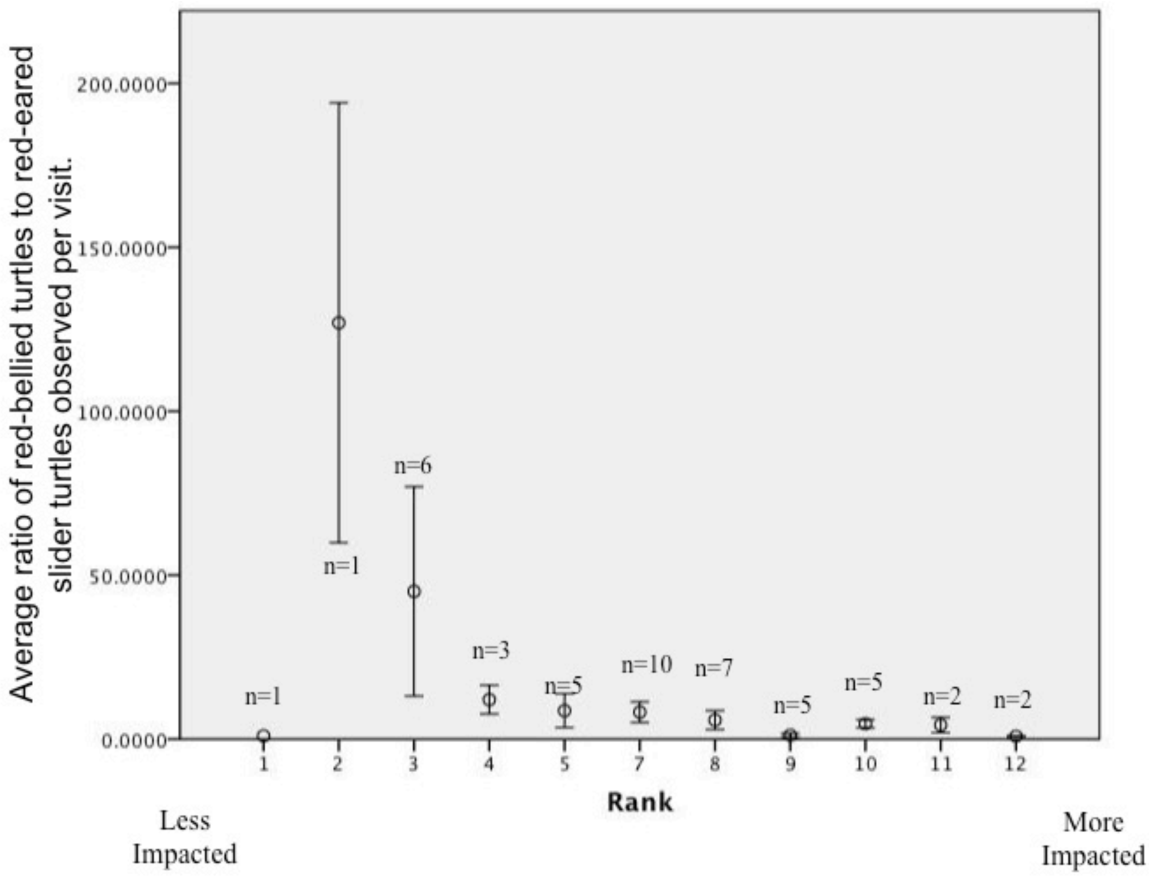

Figure 8: Ratio of red-bellied turtles to red-eared slider turtles relative to wetland rank. Low ranking wetlands are less developed, high-ranking wetlands are more developed. No turtles were observed at the four wetlands of rank 6. n = number of wetlands. All zeros replaced by 0.1 (Methods). Error bars are +/- 1 SE.

Lower relative abundance of red-bellied turtles in wetlands in public parks

A paired t-test showed that the means of the ratios of red-bellied turtles to all and red-eared slider turtles to all for wetlands in public parks were not significantly different (0.110, p = 0.24) (Figure 9). Some of these wetlands were on private land and some were on public land that was not specifically designated a public park. Public parks have signs and parking. The ratio of red-bellied turtles to all turtles was higher in wetlands not in a public park than in wetlands in public parks (Mann-Whitney U, $p = 0.002$). The ratio of red-eared slider turtles to all turtles was not significantly different between these two wetland types. A Mann-Whitney U test showed no significant difference between numbers of red-eared slider turtles inside public parks and not inside public parks ($p = .350$) (Figure 10).

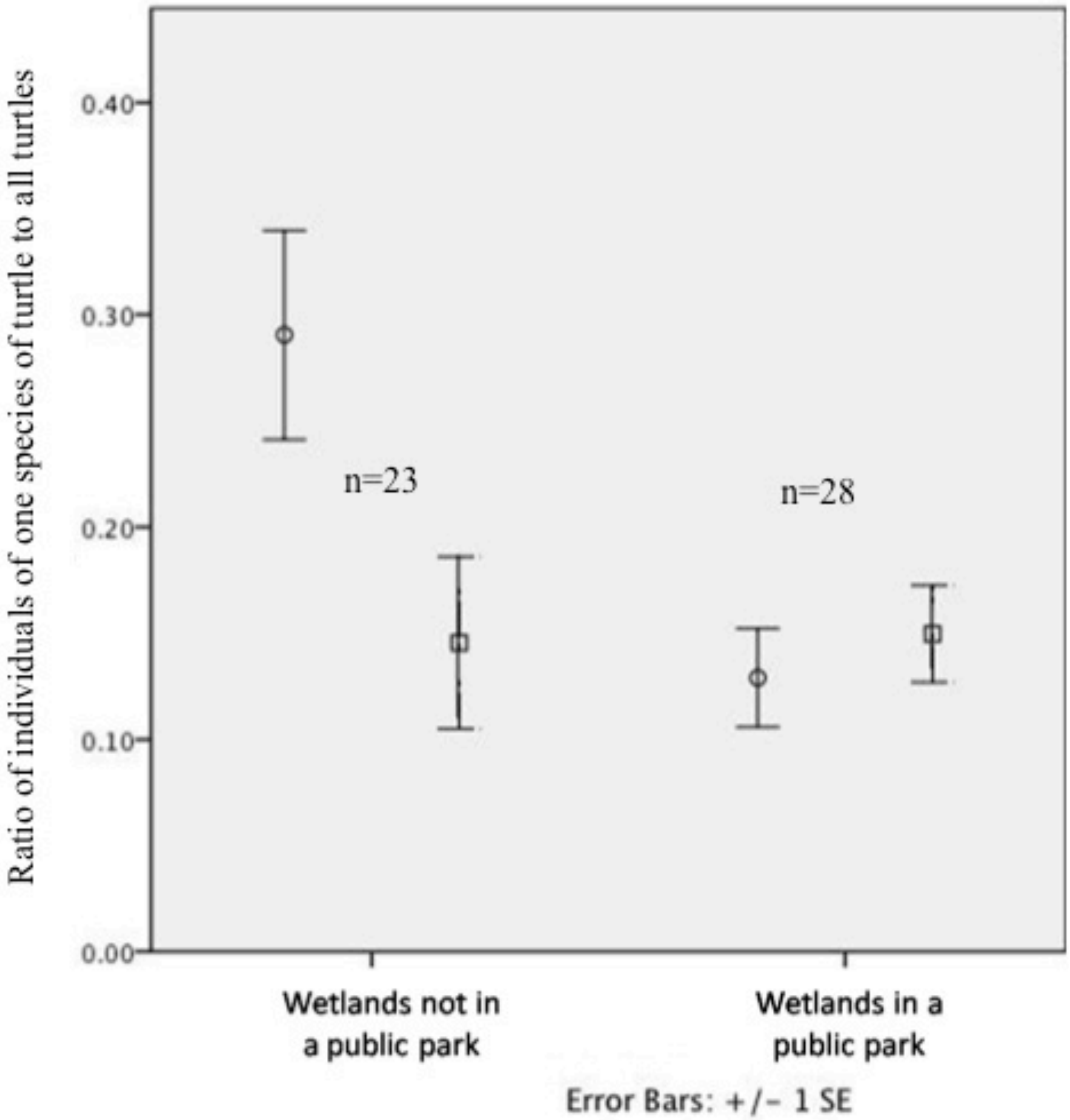

Figure 9: Ratios of red-bellied turtles (circles) and red-eared slider turtles (squares) to all turtles observed in wetlands in public parks and not in public parks. Green Lane Reservoir – Upper does not appear in this graph.

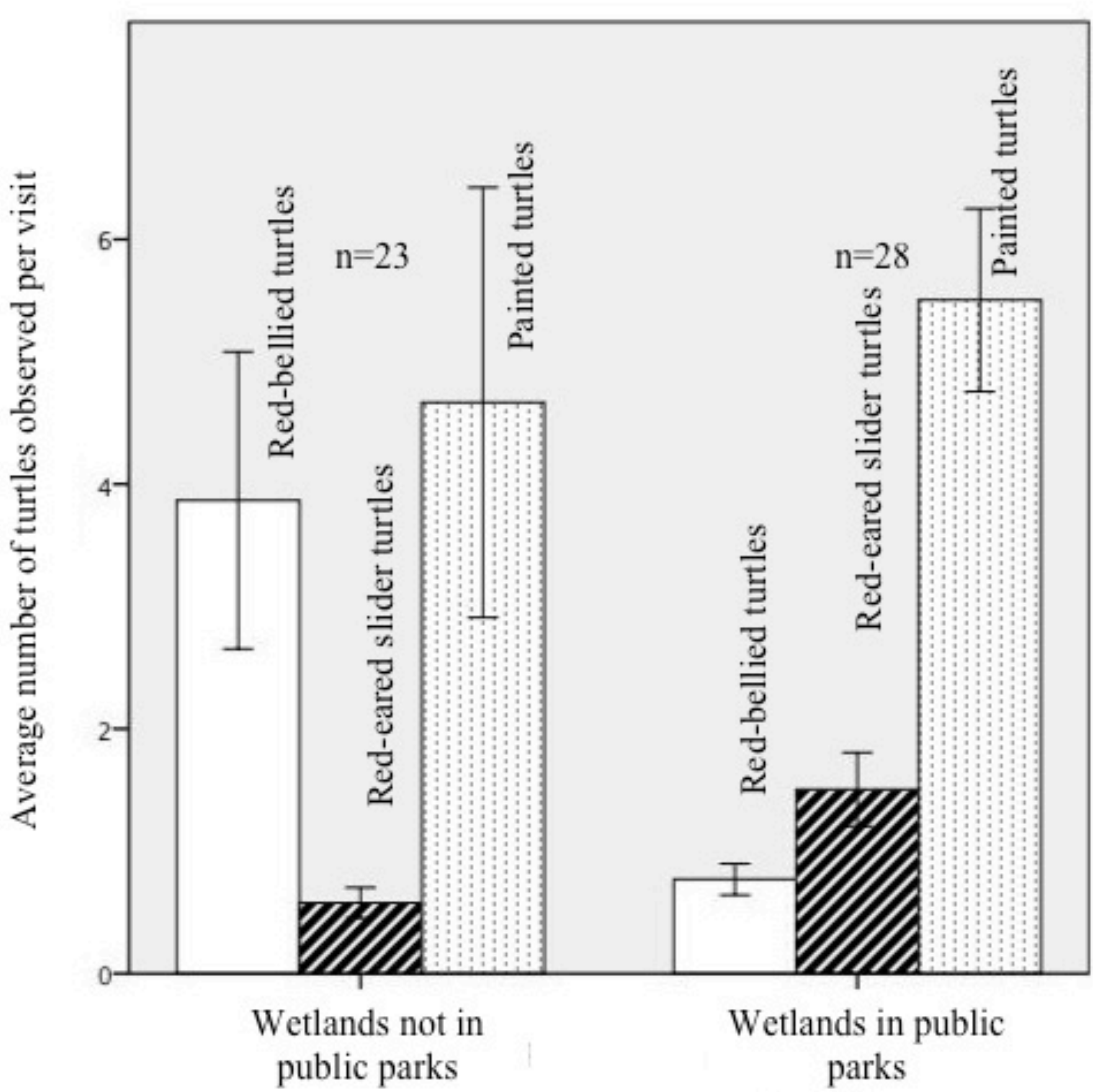

Figure 10: Average number of *P. rubriventris* (white bars), *T. scripta* (striped bars) and *C. picta* (dotted bars) observed per visit to wetlands in public parks and not in public parks. n = number of wetlands. Error bars are +/- 1 standard error.

At the two sites in the Potomac Basin (Mountain Lake and Mountain Lake Creek Road) I did not observe red-eared slider turtles. The Monocacy site was also in the Potomac Basin, but I did not observe any turtles there. At sites in the furthest east basin, the Delaware Basin, the relative abundances of red-bellied turtles and red-eared slider turtles to all turtle species were not significantly different (Figure 11). In the Potomac Basin, next to the Delaware Basin on the west, no red-eared slider turtles occurred. Further west, in the Susquehanna-Chesapeake Basin, the two ratios were also not significantly different.

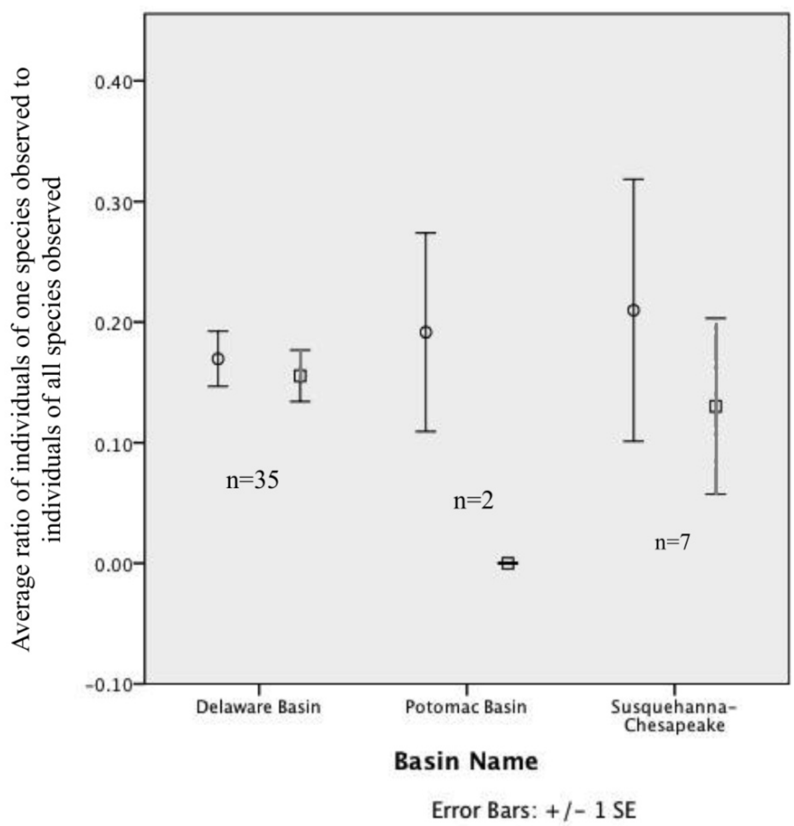

Figure 11: Ratios of Red-bellied turtles (circles) and red-eared slider turtles (squares) to all turtles in the three Basins in Southeastern PA. n=number of sites. No red-eared sliders were sighted in the Potomac Basin.

The largest numbers of red-bellied turtles were found in the two most western watersheds. In the furthest west watershed, Conococheague-Opequon, no red-eared slider turtles occurred. The highest number of red-eared slider turtles occurred in the Crosswicks-Neshaminy watershed, the second most easterly watershed (Figure 12). Painted turtles occurred in larger numbers on the western end and on the eastern end than in the middle of the study area.

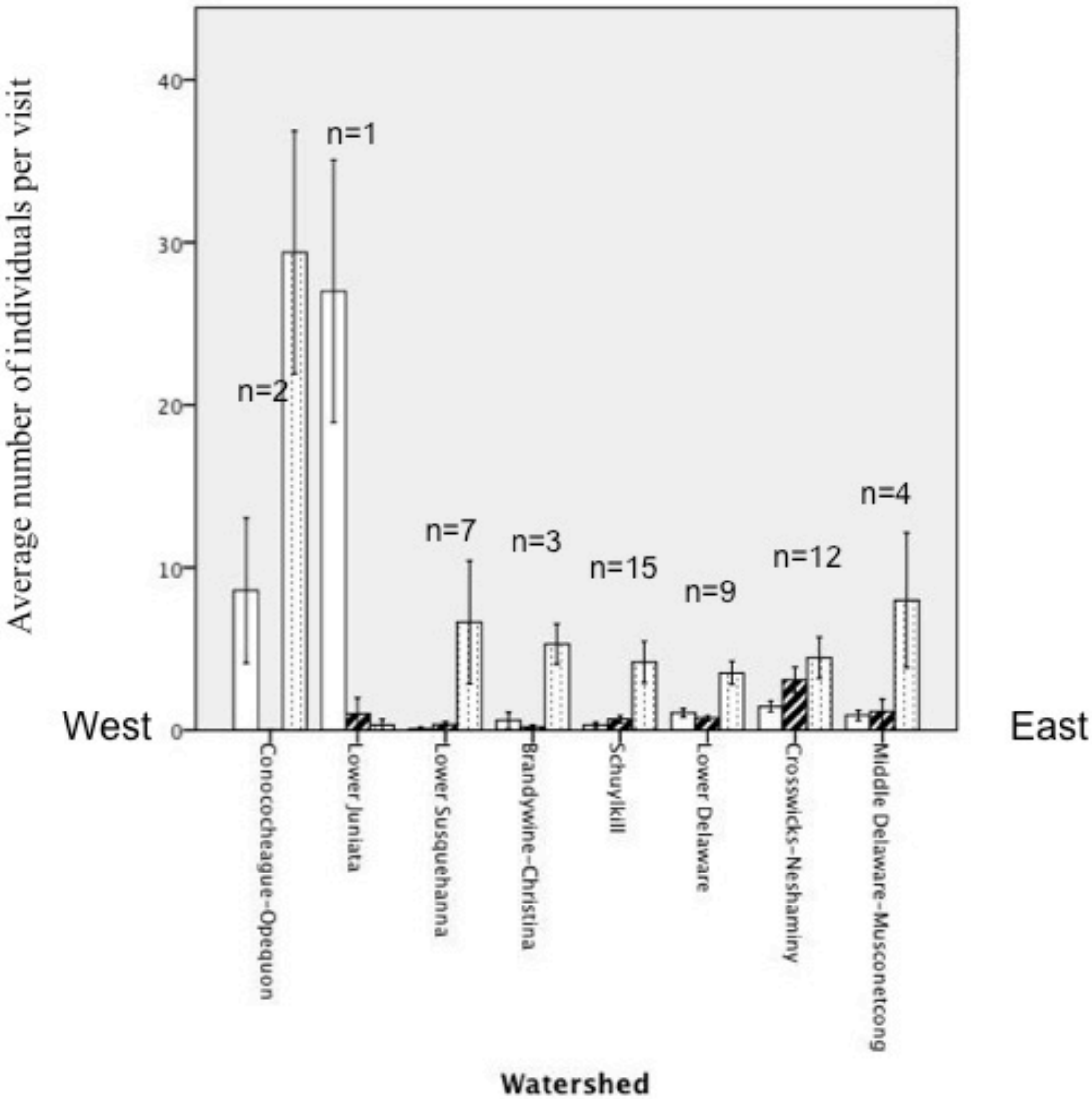

Figure 12: Average number of individual red-bellied turtles (no pattern), red-eared slider turtles (stripes), and painted turtles (dots) observed per visit. n = number of wetlands in each watershed. Error bars are +/- 1 SE.

The ratio of red-bellied turtles to all species was highest in the second most westerly county (Lower Juniata) where nearly all observed turtles were red-bellied turtles (Figure 13). The next highest ratios occurred in the two most eastern watersheds and the most western one. In the middle of the study area red-bellied turtles made up between 0 and 5% of the turtles observed. No red-eared slider turtles were observed in the watershed furthest west in the study area.

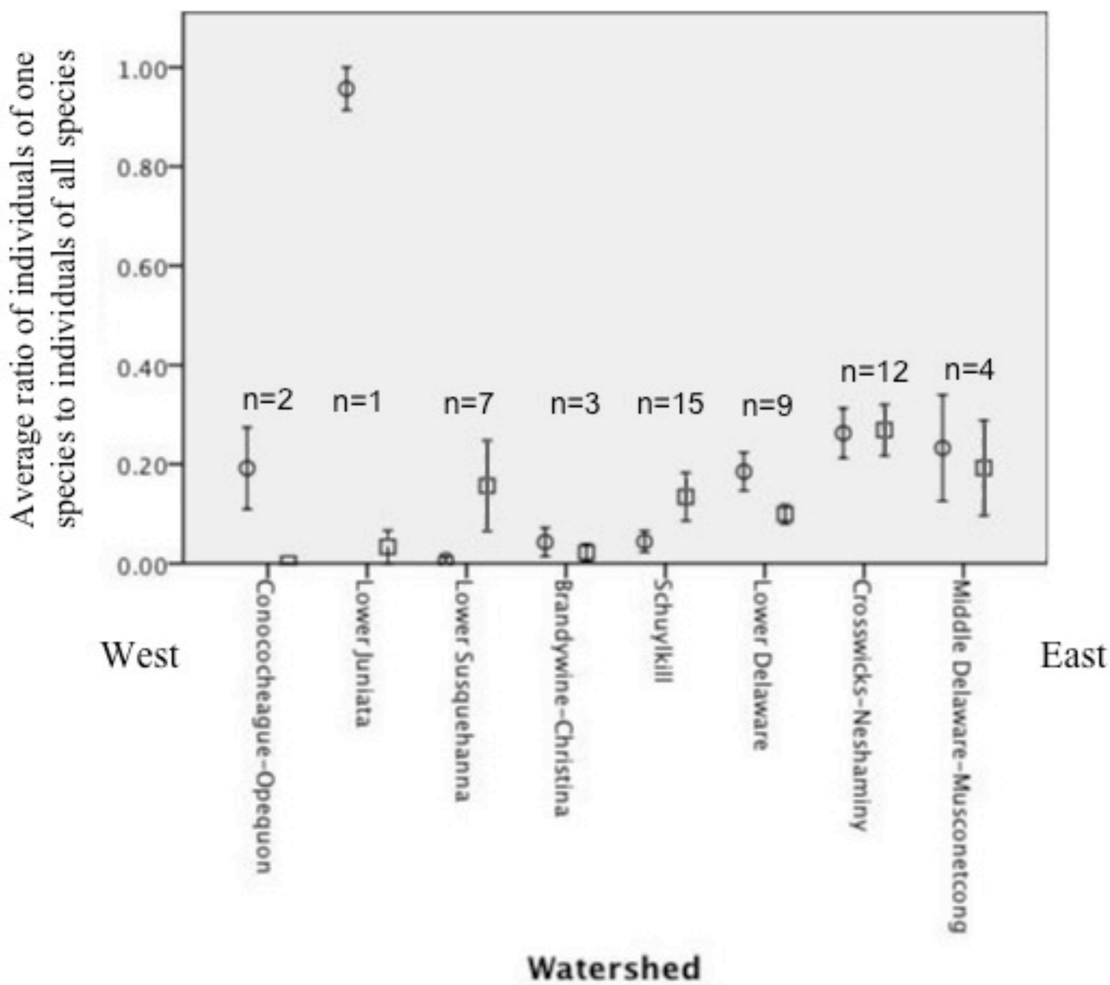

Figure 13: Ratio of Red-bellied turtles (circles) and red-eared slider turtles (squares) to all turtles by watershed. n=number of wetlands. Error bars are +/- 1 SE.

Perry County had the highest ratio of red-eared slider turtles to all turtles, followed by Delaware and Franklin Counties (Figure 14). In Berks and York, no red-eared slider turtles occurred. In Chester, Montgomery and Lancaster counties the ratio of red-eared slider turtles to all turtles was between 0.01 and 0.1. York, Bucks and Philadelphia all had high relative abundance of red-bellied turtles, as did John Heinz National Wildlife Refuge, which spanned the border between Philadelphia and Delaware counties.

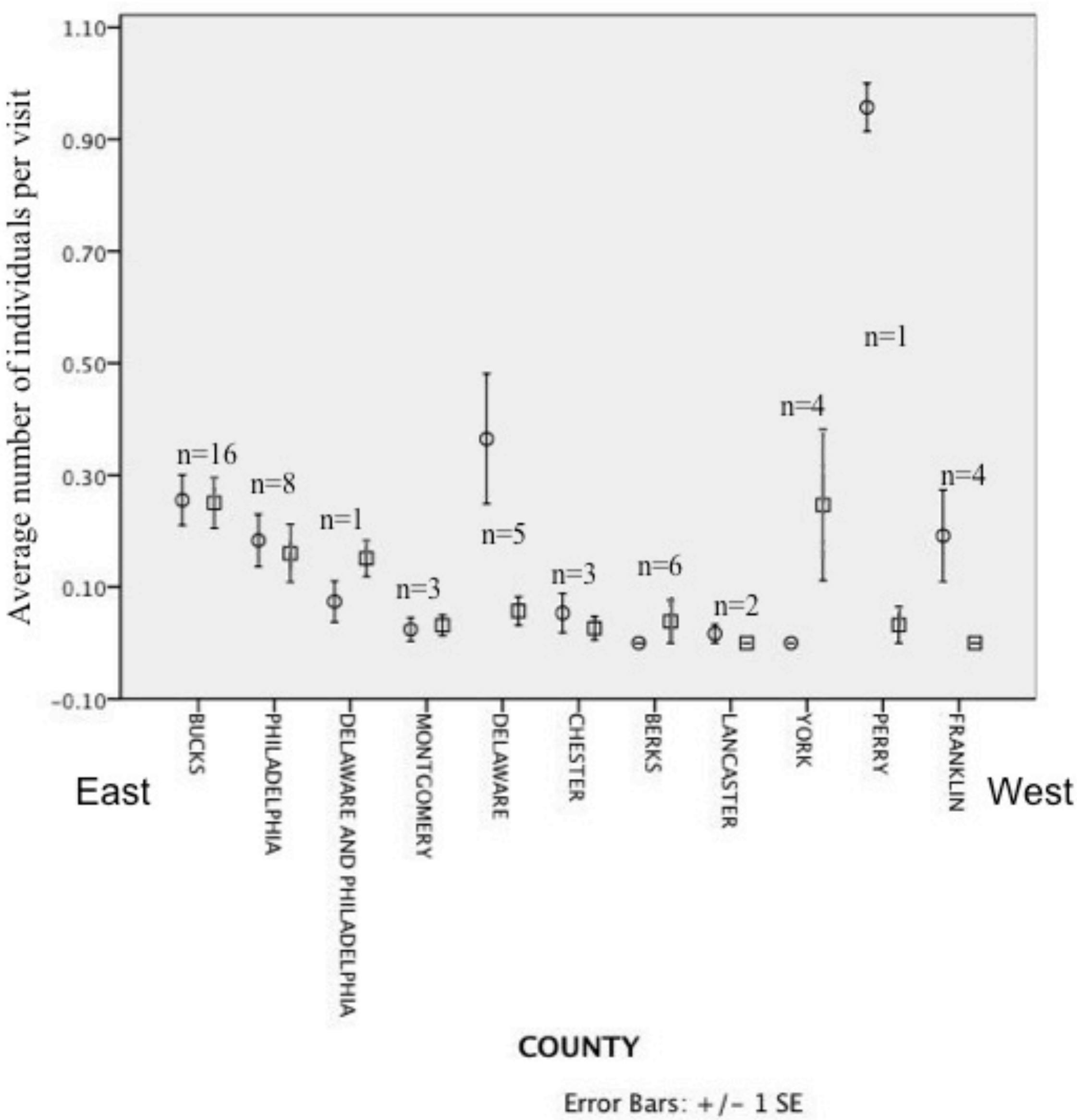

Figure 14: Ratio of red-bellied turtles to all turtles (circles) and ratio of red-eared slider turtles to all turtles (squares) by County from East to West. n is number of wetlands visited in each county.

Four observation visits were sufficient to detect turtles

I used binary logistic regression to determine if I observed enough times to detect turtles of both species in the wetland. After the fourth visit to a wetland the probability of detecting a red-bellied turtle, without having seen a red-bellied turtle on previous visits, had decreased to 0.005 or less than 1% (Figure 15). The probability of observing a red-eared slider turtle (30%) and the probability of observing both species (16%) at a wetland after the fourth visit, when no individuals of that species had been seen on previous visits, were both low (Figure 15). Four visits was adequate but five visits would have been better.

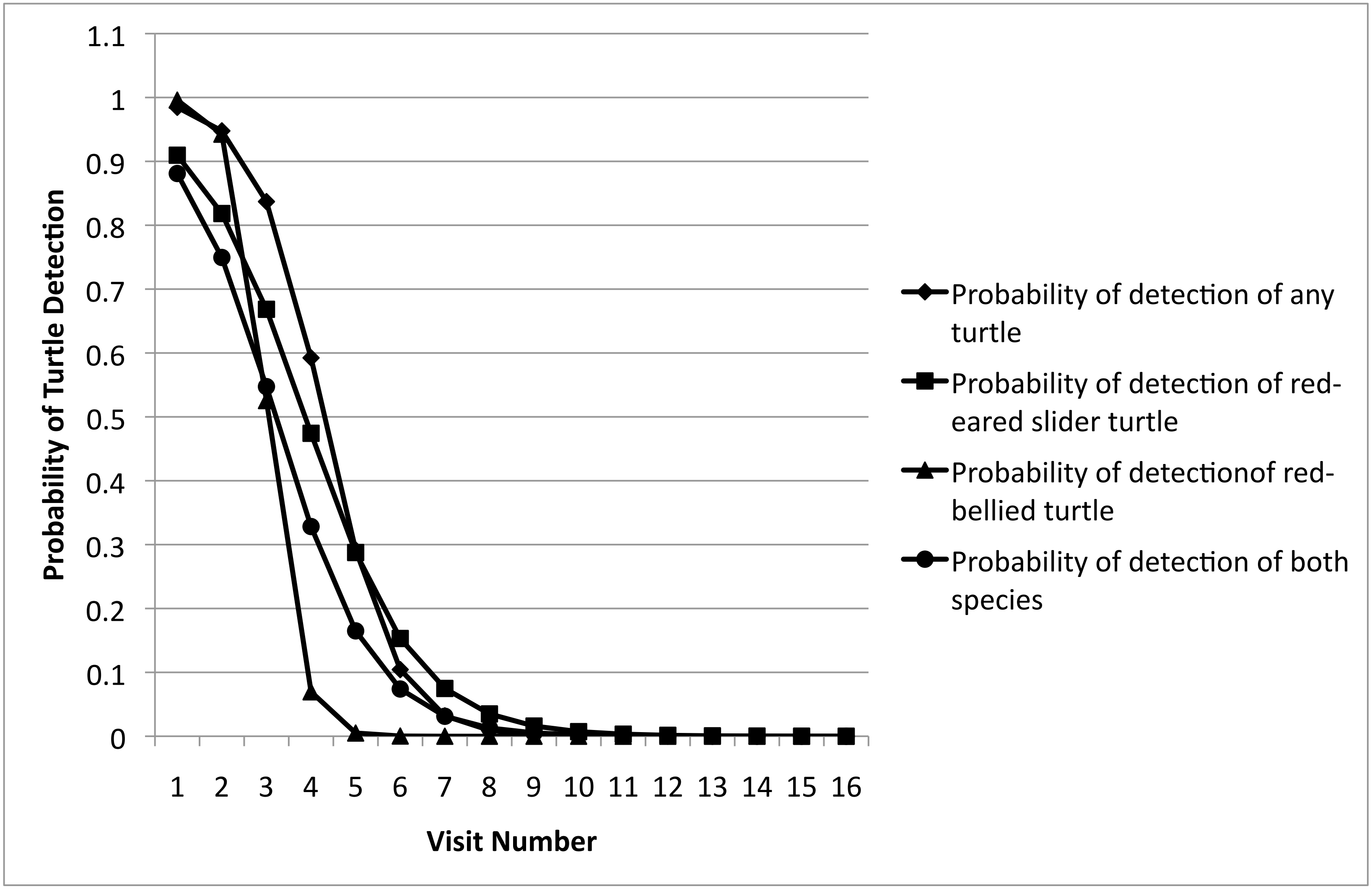

Figure 15: Probability of observing turtles at a wetland when no turtles have been observed on previous visits to that wetland by number of visits. Probability of 1 is 100% chance of detecting a turtle.

Observation and trapping methods do not reveal significantly different relative abundances

I trapped in Darby Creek at John Heinz National Wildlife Refuge in 2007 and Silver Lake Nature Center and Fort Mifflin in 2008 and 2009. Fishers Exact test for differences between numbers of turtles trapped versus numbers of turtles observed showed a difference only in *Chrysemys picta* ($p=0.008$) using data from all sites and days where both basking observations and trapping took place. I made observations of basking turtle concurrent with turtle trapping three times. In 2007 I collected both types of data at JHNWR. In 2009, I collected both types of data at the Silver Lake nature center sites and at Fort Mifflin. At John Heinz National Wildlife Refuge our 2007 observation data roughly coincided with the 2007 trapping data collected at the same site. (Figure 15, 16, Table 3, 4, 5).

I trapped turtles in Darby Creek at John Heinz National Wildlife Refuge from August 7, 2007 to September 21, 2007 for a total of 34 days and 272 trap hours. I captured more red-eared slider turtles than red-bellied turtles during the 2007 trapping season (Figure 18). The dearth of hatchlings in the trapping data is probably not reflective of small numbers of hatchlings. Both hoop-net traps with 1-inch mesh and basking traps are known to bias against capturing hatchlings. In addition, the Darby Creek site at John Heinz experiences 1.2 to 2 meter tides daily. Hatchlings may be more successful and therefore more numerous on the more protected impoundment side.

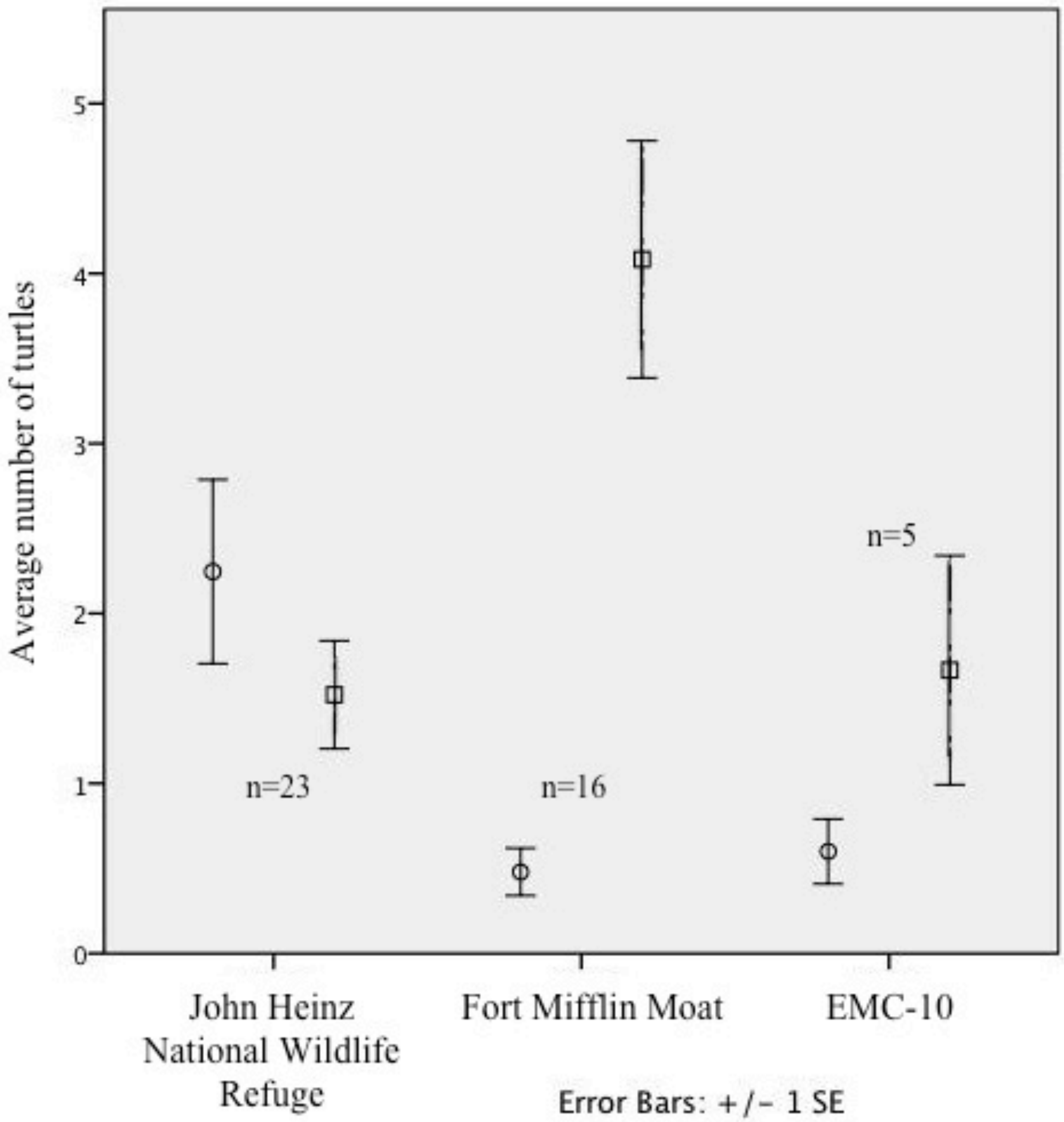

Figure 16: Observed and trapped turtles at John Heinz National Wildlife Refuge, Fort Mifflin moat and EMC-10, the pond outside Fort Mifflin. Circles are basking turtles, squares are trapped turtles. Observation and trapping data are from the same days. n = days.

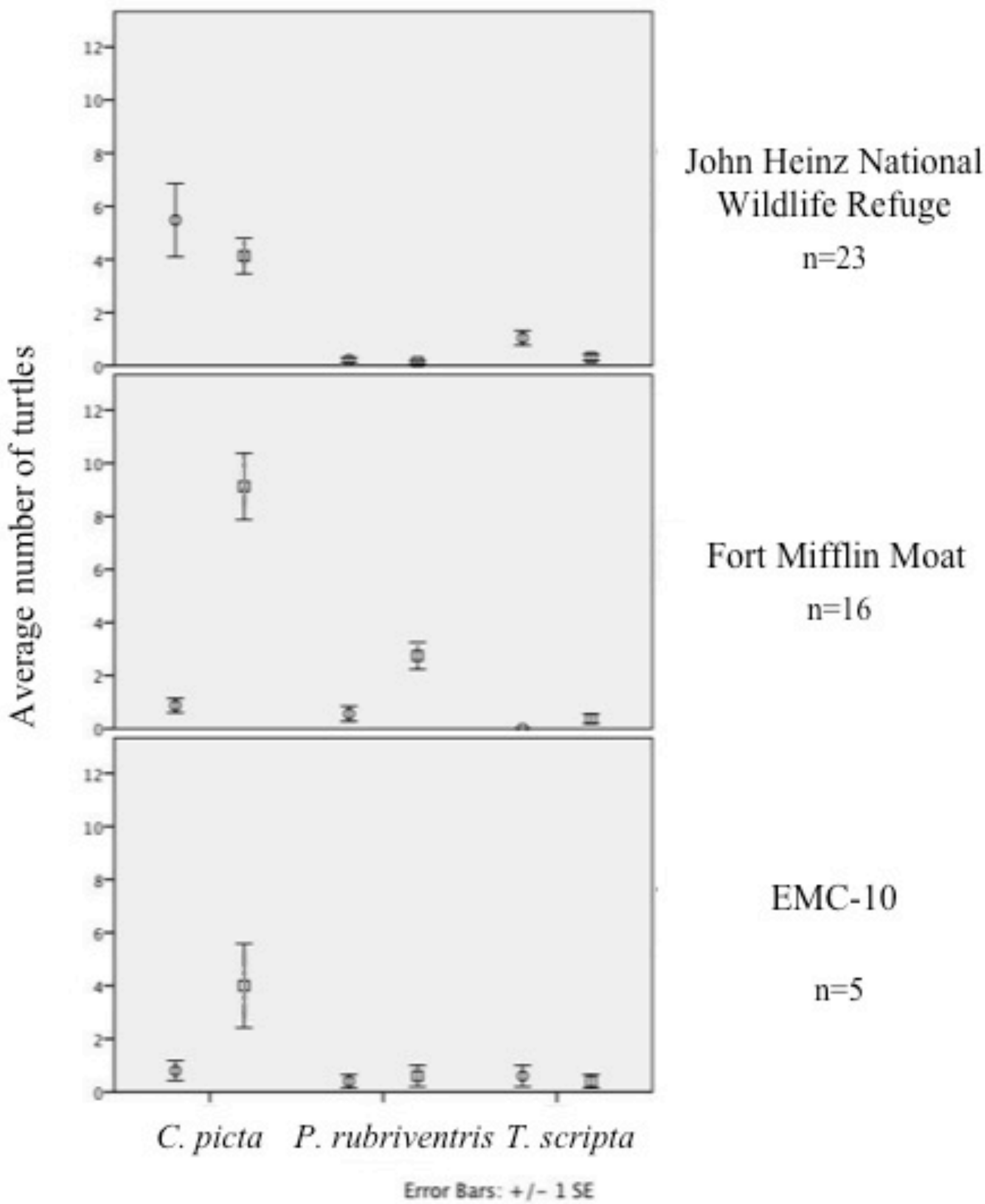

Figure 17: Observed and trapped turtles at John Heinz National Wildlife Refuge, Fort Mifflin moat and the pond outside Fort Mifflin. Circles are basking turtles; squares are trapped turtles. Observation and trapping data are from the same days. n = days.

Stage class structure from trapping data

At Darby Creek in John Heinz National Wildlife Refuge in 2007 I captured adults turtles only (Figure 18). Hatchlings and juveniles were observed at John Heinz National Wildlife Refuge in both 2006 and 2007. At Fort Mifflin in 2008 and 2009 I captured turtles of both species in all stage classes (Figure 19, Figure 20). At Silver Lake Nature Center in 2008 and 2009 I also captured turtles of both species in all age classes (Figure 21, Figure 22).

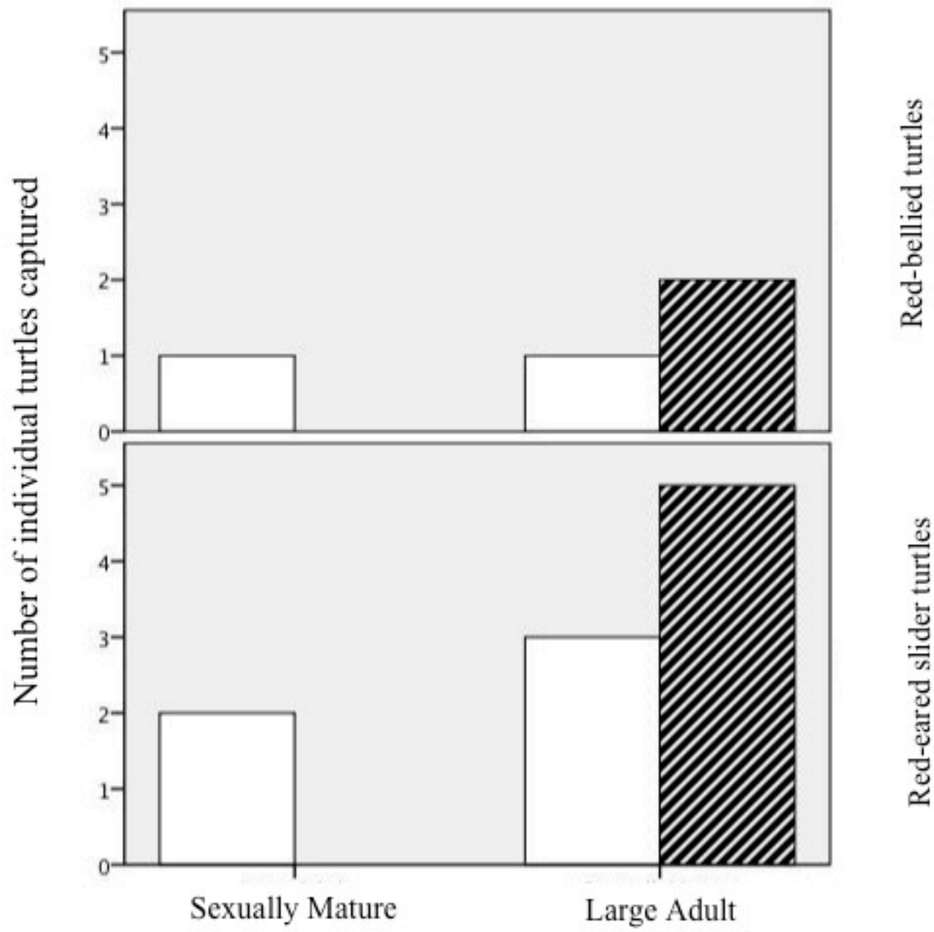

Figure 18: Stage class structure of female (white) and male (stripes) red-bellied turtles (top) and red-eared slider turtles (bottom) at John Heinz National Wildlife Refuge in Darby Creek and the impoundment in 2007 and 2009. No other stage classes were captured.

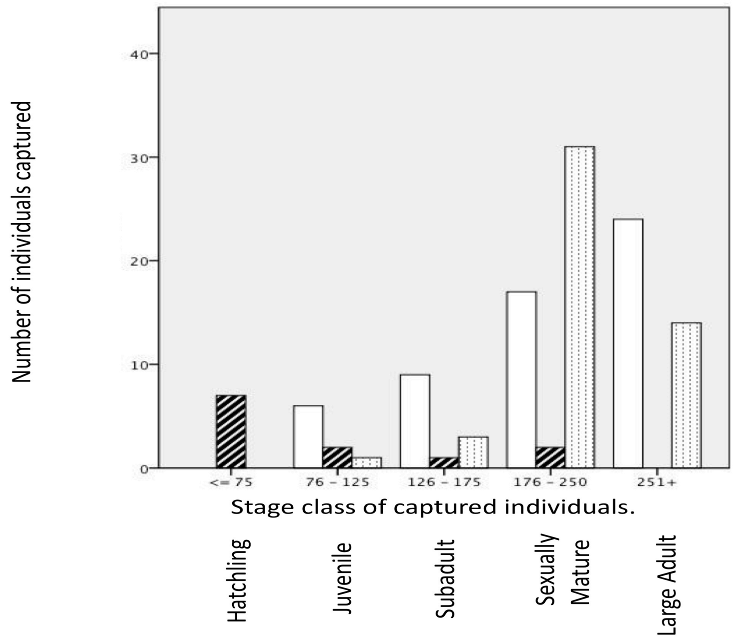

Figure 19: Female (white bars), male (dotted bars) and juvenile (striped bars) *Pseudemys rubriventris* captured at Fort Mifflin in 2008 and 2009.

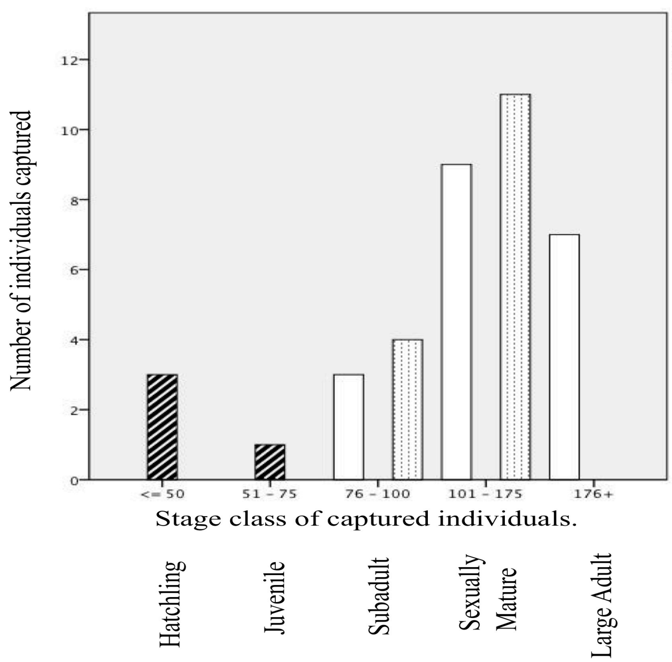

Figure 20: Female (white bars), male (dotted bars) and juvenile (striped bars) *Trachemys scripta* captured at Fort Mifflin in 2008 and 2009.

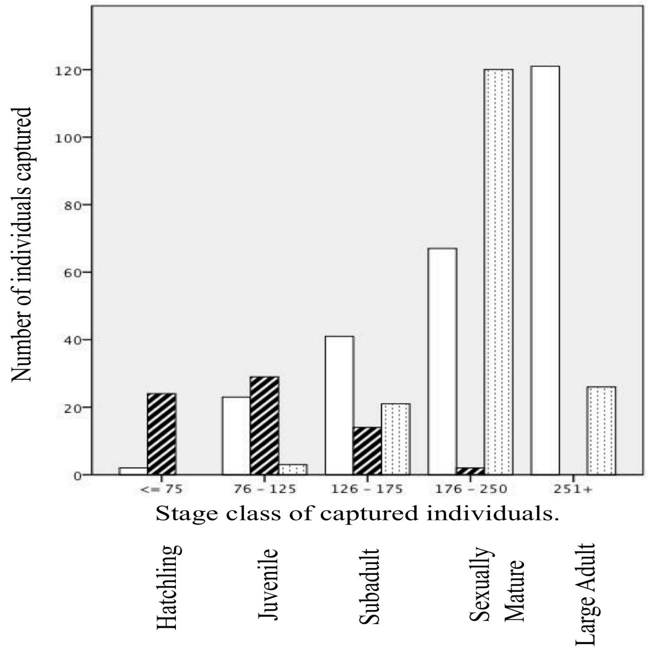

Figure 21: Female (white bars), male (dotted bars) and juvenile (striped bars) *Pseudemys rubriventris* captured at Silver Lake Nature Center in 2008 and 2009.

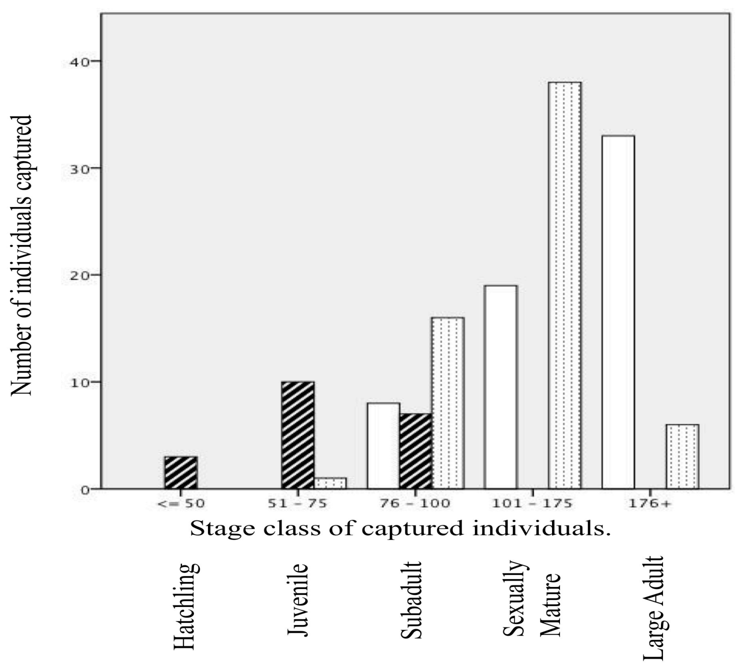

Figure 22: Female (white bars), male (dotted bars) and juvenile (striped bars) *Trachemys scripta* captured at Silver Lake Nature Center in 2008 and 2009.

Wetland size had no significant relationship to the ratio of red-bellied turtles to red-eared slider turtles (p = 0.426), number of red-bellied turtles (p = 0.285), or number of red-eared slider turtles (p = 0.751) (Figure 23).

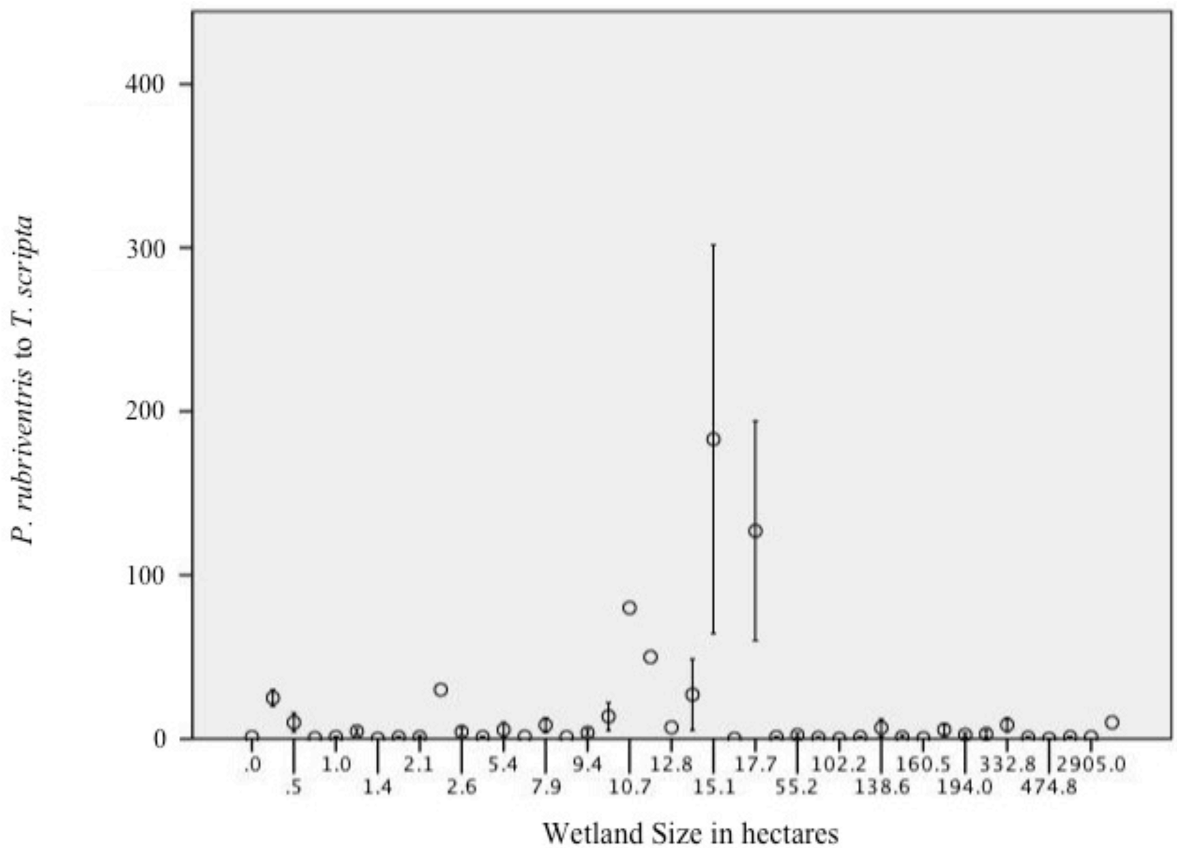

Figure 23: Red-bellied turtles to red-eared slider turtles at wetlands by size. Error bars are +/- 1 SE. No error bars indicate only one wetland at a particular size. Zeros replaced by 0.1.

Table 3: Number of individual turtles caught at Silver Lake Nature Center and Fort Mifflin Moat in 2008.

Trachemys scripta	***Hatchling***	***Juvenile Male***	***Juvenile Female***	***Juvenile***	***Adult Male***	***Adult Female***
Silver Lake South	**3**	**2**	**1**	**1**	**1**	**6**
Silver Lake North	**0**	**1**	**0**	**2**	**3**	**3**
Magnolia Lake	**0**	**9**	**6**	**5**	**17**	**22**
Silver Lake Macrosite	**3**	**12**	**7**	**8**	**21**	**31**
Fort Mifflin Moat	**0**	**0**	**2**	**1**	**8**	**8**
Pseudemys Rubriventris	***Hatchling***	***Juvenile Male***	***Juvenile Female***	***Juvenile***	***Adult Male***	***Adult Female***
Silver Lake South	**1**	**7**	**8**	**5**	**16**	**23**
Silver Lake North	**2**	**2**	**6**	**6**	**13**	**18**
Magnolia Lake	**2**	**3**	**6**	**7**	**21**	**22**
Silver Lake Macrosite	**5**	**12**	**20**	**18**	**50**	**63**
Fort Mifflin Moat	**0**	**0**	**2**	**0**	**13**	**3**

Table 4: Number of individual turtles captured in 2007 at John Heinz National Wildlife Refuge in Darby Creek.

Trachemys scripta	*Hatchling*	*Juvenile Male*	*Juvenile Female*	*Juvenile*	*Adult Male*	*Adult Female*
Darby Creek – John Heinz National Wildlife Refuge (2007)	0	0	0	0	4	3
Pseudemys Rubriventris	*Hatchling*	*Juvenile Male*	*Juvenile Female*	*Juvenile*	*Adult Male*	*Adult Female*
Darby Creek – John Heinz National Wildlife Refuge (2007)	0	0	0	0	0	2

Table 5: Number of individual turtles captured at Fort Mifflin in 2009.

Trachemys scripta	*Hatchling*	*Juvenile Male*	*Juvenile Female*	*Juvenile*	*Adult Male*	*Adult Female*
Fort Mifflin Macrosite: Moat, EMC 10 (2009)	0	7	2	4	8	15
Pseudemys Rubriventris	*Hatchling*	*Juvenile Male*	*Juvenile Female*	*Juvenile*	*Adult Male*	*Adult Female*
Fort Mifflin Macrosite: Moat, EMC 10 (2009)	7	4	13	5	32	38

Chapter 5: Discussion

At just under half the sites where *P. rubriventris* have occurred in the past, I did not find *P. rubriventris* (Figure 4). *Trachemys scripta* were present at just under half the sites surveyed (Figure 5). Since *T. scripta* is not native to this area, just under half the sites that were inhabited by red-bellied turtles have been invaded. Thus, my findings suggest that the threatened red-bellied turtle is in decline in its native range, while the invasive red-eared slider turtle is expanding its range in the same area of southeastern Pennsylvania.

The paired t-test for differences in means of *P. rubriventris* observed and *T. scripta* observed in each wetland ($n = 238$, $t = -0.781$), indicates that even though at one point there were *P. rubriventris* and no *T. scripta* at each of these sites, now there is no statistically significant difference in their occurrence. At the 52 wetlands surveyed, the two species occurred at the same rate. There was no significant difference in the number of wetland visits where red-bellied turtles occurred and the number of wetland visits where red-eared sliders occurred. Since no turtles were observed at some sites and several sites had only one species or the other, there was clearly a decline in the number of wetlands inhabited by *P. rubriventris* and an increase in the number of wetlands where *T. scripta* was present.

It is possible that the sampling method was inadequate to detect the presence of *P. rubriventris* in some cases. For example, it is known that Silver Lake South has *P. rubriventris* (Steve Pearson, personal communication; personal observation during 2008 and 2009 trapping field seasons), but I did not observe any during our 4 visits in 2006. At Magnolia Lake, one of the sites where only *P. rubriventris* were observed, there is a multi-year record of *T. scripta* captures (Steve Pearson, personal communication). Magnolia lake was not one of the sites where I observed turtles I could not identify.

The trapping data and observation data for visits on the same days corresponds fairly well (Figures 16 and 17) and the probability of detection (Figure 15) shows that I was unlikely to observe red-eared slider turtles and red-bellied turtles at wetlands I had not already observed them at after 4 visits. The anecdotal support for non-correspondence of trapping data and observational data should be a reminder to use caution and good judgment interpreting findings, but should not mean that the observational sampling method is inadequate.

The presence of *P. rubriventris* at 8 wetlands where *T. scripta* were not seen implies at least two possibilities: (1) These 8 wetlands are resistant to invasion by *T. scripta* and have remained suitable habitat for *P. rubriventris*; or (2) These wetlands have not been subject to invasion pressure by *T. scripta*.

Negative correlation between human impact ranking of wetland and relative abundance of red-bellied turtles.

The red-bellied turtle uses upland areas up to 225 m (0.225 km) from the wetland edge for nesting in Maryland (Swarth 2003). In South Carolina a 275 meter (0.275 km) upland buffer zone is required to protect 100% of freshwater turtle nest and hibernation sites (Burke and Gibbons 1995). Cagle (1950) reported *T. scripta* traveling overland up to 1.6 km (1600m) to a suitable nesting site in Louisiana. In the tropics, Moll and Legler (1971) found females traveling up to 0.4 km (400 m) to a nest site. For this reason I assigned points to wetlands for types of development, such as roads, houses or other buildings, parking lots or channelized wetland edges, within the 275m wetland edge buffer needed to protect turtle nesting sites.

Garber and Burger (1995) measured human accessibility by the number of permits to walk in a protected watershed in south-central Connecticut issued per year and found a negative relationship between the number of permits issued and the number of wood turtles, *Clemmys insculpta*, captured. My ranking system also measured human accessibility. For this reason I chose to assign points for roads, bridges and other access points as well as for the presence of people at a site during basking turtle observation. Points for nearby houses and being in a public park were also measures of ease of access for humans.

I found that the more highly impacted wetlands had a lower ratio of red-bellied turtles to red-eared slider turtles (Figure 8). This was due to smaller numbers of red-bellied turtles at more highly impacted wetlands (Figure 7). The reduced numbers of red-bellied turtles at these more highly impacted wetlands indicates that red-bellied turtles reside in smaller numbers in wetlands impacted by paved or mowed shorelines or other upland disturbances. There were several wetlands: Lake Galena – Rank 8, Silver Lake Nature Center – Rank 3 and Rank 9, John Heinz – Rank 7 (Table 2), with heavy human foot traffic where the wetland edges were not mowed or paved but were maintained either as meadows or tree line. At these wetlands both red-bellied turtles and red-eared slider turtles were present. This may indicate that the presence of humans in restricted areas near the wetland is not a problem for red-bellied turtles. When human traffic is restricted to pathways and bridges and wetland edges are not mowed or paved, red-bellied turtles are present despite heavy human use.

Relative abundance of red-bellied turtles and red-eared slider turtles in wetlands inside and outside of public parks.

There was a higher relative abundance of red-bellied turtles than red-eared slider turtles at wetlands outside of parks compared to wetlands inside parks (Figure 9). In addition to protecting public park wetlands it is also important to protect wetlands that may either be privately owned or on public property that is not within a park. This could mean there is more pressure on red-bellied turtles inside of parks. Since the number of red-eared slider turtles is not significantly different inside and outside of parks, the lower numbers of red-bellied turtles inside parks is probably not due to competition with red-eared slider turtles.

At sites like Lake Galena, where turtles see humans frequently and are not harassed I saw little response to our appearance. At sites where turtles had less frequent contact with humans the turtles left their basking perches for the safety of the water as I approached. It is possible that numbers of turtles inside parks are over-represented due to acclimation to people. At John Heinz this did not seem to be the case; turtles rapidly took cover in the water as we approached.

Geographical gap in red-eared slider turtle distribution

No red-eared slider turtles were observed in the Potomac Basin, which was between the native range of red-eared slider turtle and many of the wetlands where red-eared slider turtles were present (Figure 11). The geographical gap in red-eared slider turtle distribution makes it unlikely that red-eared slider turtles are moving unaided across the landscape from their native Mississippi Valley watershed towards Philadelphia. The patchy distribution of the red-eared slider turtles may be due to human release of red-eared slider turtles occurring in some areas of southeastern Pennsylvania but not in others.

More red-bellied turtles are present in the western watersheds while more red-eared slider turtles are present in eastern watersheds.

The patchy distribution pattern is also evident at the watershed level (Figure12, 13). The western edge of the known range of red-bellied turtle habitat is further from the extreme development pressures of the Philadelphia area. There are still city centers in the western edge but they are not under the same amount of development pressure. The Philadelphia area has experienced a housing boom in the last several years. An increase in human habitation and mowed or paved wetland edges may accompany a housing boom. Many of the more highly disturbed sites (see ranking section) had mowed or paved wetland edges. Thus red-bellied turtles are still present in western watersheds, absent from wetlands in the middle of our study area and present but in lower numbers in watersheds closer to the population center of Philadelphia. For red-eared slider turtles the opposite trend is true. There are more red-eared slider turtles in eastern watersheds, especially in the Philadelphia area.

Trapping and observation of basking turtles does not give significantly different results except possibly for painted turtles.

In most cases the numbers of red-eared slider turtles, red-bellied turtles, and painted turtles were not significantly different between trapping and basking (Figure 15, Figure16). More foot traffic at the Fort Mifflin Moat may explain the lower numbers of basking turtles observed at the moat compared to the other two sites. Painted turtles were captured in larger numbers than they were observed at both Fort Mifflin and EMC-10 (the pond outside the Fort Mifflin gates) sites but the opposite was true at John Heinz National Wildlife Refuge. Red-bellied turtles were trapped in slightly higher numbers than they were observed at the Fort Mifflin moat and red-eared slider turtles were seen basking in higher numbers at John Heinz National Wildlife refuge, but were trapped in higher numbers at Fort Mifflin (Figure 16). Since these differences are not significant and are in different directions, presence of red-eared slider turtles and red-bellied turtles can be established by the observation method. Trapping data is still useful for population size estimates and stage class data but for a rapid assessment of relative abundances, the observation method is sufficient.

Directions for future research

Future research should focus on experimental studies to determine the extent of competition between the two species, aquatic conditions in the wetlands (temperature, salinity, diversity and abundance of foods available), and intensive trapping. Intensive trapping can establish population sizes and vital rates. These are essential to determine the likelihood of a population's continued presence in a wetland.

Another useful direction for future research is public education. Is there a correlation between posted "don't release red-eared slider turtles" signs and the population size of red-eared slider turtles? Are formal presentations or community events correlated with the size of populations of red-eared slider turtles? Does the population size decrease in years following formal presentations or community events? What about posting the names and addresses of turtle rescue operations at wetlands so people who were headed to a wetland to release a pet could have information available to them at the time they needed it?

The 7 sites where T. scripta was observed and P. rubriventris was not could be sites that have become unsuitable for P. rubriventris, due to human impact or examples of T. scripta out-competing P. rubriventris. Four wetlands had ranks of 7 or 8 while the remaining 3 wetlands were all of rank 3 on the human impact scale. These lower ranked wetlands should be investigated to determine if the cause of decline in red-bellied turtles was competition with red-eared slider turtles.

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Appendix A: Observation and Trapping Data

Table 6: Observation and trapping data at John Heinz National Wildlife Refuge 2006

* 2006 Includes observations in the impoundment and in Darby Creek											
		Pseudemys rubriventris		*Trachemys scripta*		*Chrysemys picta*		*Cheyldra serpentina*		Species undetermined	
2006 Visit Number	Date	Number of Basking turtles observed	No Trapping	Number of Basking turtles observed	No Trapping	Number of Basking turtles observed	No Trapping	Number of Basking turtles observed	No Trapping	Number of Basking turtles observed	No Trapping
1	1-Jun-06	6		3		7		0		0	
2	14-Jun-06	0		0		0		0		0	
3	22-Jun-06	0		0		0		0		0	
4	30-Jun-06	2		0		1		0		0	
5	11-Aug-06	0		0		0		0		0	
Total Observations		8		3		8		0		0	

Table 7: Observation and trapping data at John Heinz National Wildlife Refuge, 2007

*2007 includes only Darby Creek											
**two basking visits, averages reported for visit		*Pseudemys rubriventris*		*Trachemys scripta*		*Chrysemys picta*		*Cheyldra serpentina*		Species undetermined	
2007 Visit Number	Date	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped
1	7-Aug	1	0	1	0	5	1	0	0	2	0
2	8-Aug	0	0	0	1	5	3	0	0	0	0
3	9-Aug	0	no trapping	0	no trapping	0	no trapping	0	no trapping	0	no trapping
4	10-Aug	0	0	0	0	0	5	0	0	1	0
5	13-Aug	1	0	1	0	6	4	0	1	0	0

Table 7 continued: Observation and trapping data at John Heinz National Wildlife Refuge, 2007

*2007 includes only Darby Creek												
**two basking visits, averages reported for visit		*Pseudemys rubriventris*		*Trachemys scripta*		*Chrysemys picta*		*Cheyldra serpentina*		Species undetermined		
2007 Visit Number	Date	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	
6	14-Aug	1	0	1	0	6	5	0	0	0	0	
7	15-Aug	0	0	0	0	2	11	0	1	0	0	
8	16-Aug	0	0	0	0	0	4	0	0	0	0	
9	17-Aug	1	0	5	0	15	7	0	0	0	0	
10	23-Aug	0	0	2	0	6	1	0	0	0.5	0	

Table 7 continued: Observation and trapping data at John Heinz National Wildlife Refuge, 2007

*2007 includes only Darby Creek													
**two basking visits, averages reported for visit		*Pseudemys rubriventris*		*Trachemys scripta*		*Chrysemys picta*		*Cheyldra serpentina*		Species undetermined			
2007 Visit Number	Date	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped		
11	24-Aug	no observation	0	no observation	0	no observation	7	no observation	0	no observation	0		
12	28-Aug	no observation	0	no observation	0	no observation	3	no observation	0	no observation	0		
13	29-Aug	no observation	1	no observation	0	no observation	1	no observation	0	no observation	0		
14	30-Aug	0	1	1	0	7	4	0	0	0	0		

Table 7 continued: Observation and trapping data at John Heinz National Wildlife Refuge, 2007

*2007 includes only Darby Creek												
**two basking visits, averages reported for visit		*Pseudemys rubriventris*		*Trachemys scripta*		*Chrysemys picta*		*Cheyldra serpentina*		Species undetermined	
2007 Visit Number	Date	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped
15	31-Aug	0	0	2	0	26	13	0	0	0	0
16	4-Sept	0	0	1	1	5	3	0	0	0	0
17	5-Sept	no observation	0	no observation	1	no observation	5	no observation	1	no observation	0
18	7-Sept	no observation	1	no observation	2	no observation	6	no observation	0	no observation	0
19	12-Sept	0	0	1	0	5	4	0	0	0	0

Table 7 continued: Observation and trapping data at John Heinz National Wildlife Refuge, 2007

*2007 includes only Darby Creek											
**two basking visits, averages reported for visit		*Pseudemys rubriventris*		*Trachemys scripta*		*Chrysemys picta*		*Cheyldra serpentina*		Species undetermined	
2007 Visit Number	Date	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped
20	13-Sept	0	0	0	0	4	4	0	0	0	0
21	14-Sept	no observation	0	no observation	0	no observation	1	no observation	1	no observation	0
22	18-Sept	0	0	1	0	1	3	0	0	0	0
23	19-Sept	no observation	0	no observation	1	no observation	0	no observation	0	no observation	0
24	20-Sept	0	no trapping	0	no trapping	0	no trapping	0	no trapping	0	no trapping

Table 7 continued: Observation and trapping data at John Heinz National Wildlife Refuge, 2007

*2007 includes only Darby Creek											
**two basking visits, averages reported for visit		*Pseudemys rubriventris*		*Trachemys scripta*		*Chrysemys picta*		*Cheyldra serpentina*		Species undetermined	
2007 Visit Number	Date	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped	Number of Basking Turtles Observed	Number of Turtles Trapped
25	21-Sept	no observation	0	no observation	1	no observation	0	no observation	0	no observation	0
Total Observations or Captures		4	3	16	7	93	95	0	4	3.5	0
Number of Individuals			3		7		62	0	4		0

Table 8: Number of red-bellied turtles (*Pseudemys rubriventris*) and red-eared slider turtles (*Trachemys scripta*) sighted during each visit to each Southeastern Pennsylvania wetland where red-bellied turtles have been documented. (x, shading = no data)

	Number of visits	Observation Visit Number 1		Observation Visit Number 2		Observation Visit Number 3		Observation Visit Number 4		Observation Visit Number 5		Observation Visit Number 6		Observation Visit Number 7		Observation Visit Number 8		Observation Visit Number 9		Observation Visit Number 10	
Wetland		PR	TS	PR	TS	PR	TS	PR	TS	PR	TS	PR	TS	PR	TS	PR	TS	PR	TS	PR	TS
AFTON LAKE	4	1	2	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x
BLUE MARSH LAKE	6	0	0	0	0	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x
CAR WASH MARSH	4	1	1	1	0	7	0	2	0	x	x	x	x	x	x	x	x	x	x	x	x
CHADDS FORD	4	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x
CHURCHVILLE RESERVOIR	8	0	3	2	1	0	0	0	0	3	1	0	1	1	0	0	3	x	x	x	x
CONEWAGO CREEK (RTE 15)	4	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x
CRUM CREEK RESERVOIR	4	2	1	9	1	3	1	0	0	x	x	x	x	x	x	x	x	x	x	x	x
DELAWARE AT BRISTOL	4	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x
DELAWARE AT PHILADELPHIA	4	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x
FORT MIFFLIN	2	2	0	2	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
GREEN LANE RESERVOIR LOWER	7	0	2	0	0	0	0	3	2	1	0	0	0	0	1	x	x	x	x	x	x

Table 8 continued: Number of red-bellied turtles (*Pseudemys rubriventris*) and red-eared slider turtles (*Trachemys scripta*) sighted during each visit to each Southeastern Pennsylvania wetland where red-bellied turtles have been documented. (x, shading = no data)

	Number of visits	Observation Visit Number 1		Observation Visit Number 2		Observation Visit Number 3		Observation Visit Number 4		Observation Visit Number 5		Observation Visit Number 6		Observation Visit Number 7		Observation Visit Number 8		Observation Visit Number 9		Observation Visit Number 10	
GREEN LANE RESERVOIR UPPER	3	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HOPEWELL LAKE	7	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x
DARBY CREEK JOHN HEINZ (1 to 10)	30	6	3	0	0	2	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
DARBY CREEK JOHN HEINZ (11 to 20)	---	0	0	0	1	1	1	0	0	0	0	1	4	1	1	0	0	0	0	1	4
DARBY CREEK JOHN HEINZ (21 to 30)	---	0	4	0	0	0	1	0	2	0	1	0	1	0	1	0	1	0	0	0	1
JUNIATA RIVER	4	13	0	0	0	41	0	27	3	x	x	x	x	x	x	x	x	x	x	x	x
MAGNOLIA/LA GENFELDER LAKE	5	0	0	0	0	3	0	1	0	0	0	x	x	x	x	x	x	x	x	x	x
LAKE GALENA	10	1	0	0	9	0	4	0	11	0	8	1	19	x	x	x	x	x	x	x	x
PEACE VALLEY	4	1	3	2	20	2	6	0	11	x	x	x	x	x	x	x	x	x	x	x	x
LAKE MARBURG	4	0	0	0	1	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x
LAKE NOCKAMIXON	9	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	x	x

Table 8 continued: Number of red-bellied turtles (*Pseudemys rubriventris*) and red-eared slider turtles (*Trachemys scripta*) sighted during each visit to each Southeastern Pennsylvania wetland where red-bellied turtles have been documented. (x, shading = no data)

	Number of visits	Observation Visit Number 1		Observation Visit Number 2		Observation Visit Number 3		Observation Visit Number 4		Observation Visit Number 5		Observation Visit Number 6		Observation Visit Number 7		Observation Visit Number 8		Observation Visit Number 9		Observation Visit Number 10	
LAKE ONTELAUNEE	4	0	0	0	0	0	1	0	0	x	x	x	x	x	x	x	x	x	x	x	x
LAKE WARREN	8	0	0	0	0	0	0	0	0	4	0	1	4	0	0	0	0	x	x	x	x
LAKE WILLIAMS	4	0	0	0	0	0	1	0	0	x	x	x	x	x	x	x	x	x	x	x	x
LITTLE TINICUM ISLAND	5	0	0	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x
LOWER SUSQUEHANA	3	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MAIDEN CREEK	2	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MAIDEN CREEK (CHRISTMAN LAKE)	2	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MANOR SCHOOL POND	5	7	1	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x
MARSH CREEK	8	0	0	0	0	0	0	0	1	1	0	0	0	0	0	5	1	x	x	x	x
MIDDLE CREEK LAKE	4	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x
MONOCACY	1	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MOUNTAIN LAKE	3	0	0	23	0	15	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Table 8 continued: Number of red-bellied turtles (*Pseudemys rubriventris*) and red-eared slider turtles (*Trachemys scripta*) sighted during each visit to each Southeastern Pennsylvania wetland where red-bellied turtles have been documented. (x, shading = no data)

	Number of visits	Observation Visit Number 1		Observation Visit Number 2		Observation Visit Number 3		Observation Visit Number 4		Observation Visit Number 5		Observation Visit Number 6		Observation Visit Number 7		Observation Visit Number 8		Observation Visit Number 9		Observation Visit Number 10	
MOUNTAIN LAKE - CREEK ROAD	2	3	0	2	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MOUTH OF THE SCHUYLKILL	2	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
NESHAMINY CREEK	6	0	0	2	0	1	0	0	0	0	1	0	0	x	x	x	x	x	x	x	x
NORTH OF HOG ISLAND ROAD	3	3	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x
NORTHKILL CREEK	4	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x
PENN WARNER CLUB SITE	4	1	1	2	0	1	0	3	0	x	x	x	x	x	x	x	x	x	x	x	x
PENNSBURY MANOR	4	1	3	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x
POTTSTOWN	6	0	0	0	0	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x
REDMAN LAKE	4	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x
ROHM AND HAAS PONDS	4	2	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x
ROOSEVELT PARK - MEADOW LAKE	2	0	0	1	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ROOSEVELT PARK - CREEK	4	1	3	0	4	0	3	0	0	x	x	x	x	x	x	x	x	x	x	x	x

Table 8 continued: Number of red-bellied turtles (*Pseudemys rubriventris*) and red-eared slider turtles (*Trachemys scripta*) sighted during each visit to each Southeastern Pennsylvania wetland where red-bellied turtles have been documented. (x, shading = no data)

	Number of visits	Observation Visit Number 1		Observation Visit Number 2		Observation Visit Number 3		Observation Visit Number 4		Observation Visit Number 5		Observation Visit Number 6		Observation Visit Number 7		Observation Visit Number 8		Observation Visit Number 9		Observation Visit Number 10	
ROOSEVELT PARK - EDGEWOOD LAKE	3	4	3	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ROOSEVELT PARK - LOWER MEADOW	3	0	2	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x
RTE 76	3	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SILVERLAKE NORTH	6	6	2	0	0	0	0	0	0	0	0	2	0	x	x	x	x	x	x	x	x
SILVER LAKE SOUTH	5	0	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x
SUSQUEHANNA RIVER	1	1	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
VALLEY FORGE WETLANDS	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	x	x	x
WASHINGTON CROSSING	7	1	9	1	0	1	0	1	2	0	0	0	0	0	0	x	x	x	x	x	x
WHEAT SHEAF POND	5	0	0	0	0	0	0	0	0	5	0	x	x	x	x	x	x	x	x	x	x

Table 9: Number of *T. scripta* observed at John Heinz NWR during each visit in 2006 and 2007 compared to number trapped on each visit in 2007. (No trapping was done in 2006.)

Trachemys scripta	
2006 Visit Number (JHNWR)	**Number of basking *Trachemys scripta* turtles observed**
1	3
2	0
3	0
4	0
5	0
6	0
7	0

2007 Visit Number (JHNWR)	**Number of basking turtles observed**	**Number of turtles trapped**
1	1	0
2	0	1
3	0	0
4	0	0
5	1	0
6	1	0
7	1	0
8	0	0
9	0	0
10	0	0
11	0	0
12	4	0
13	4	0
14	4	0
15	0	1
16	1	1
17	2	2
18	1	0
19	1	0
20	1	0
21	1	0
22	1	1
23	0	1
Total	24	7
Individuals		7

Table 10: Number of *P. rubriventris* observed at John Heinz NWR during each visit in 2006 and 2007 compared to number trapped on each visit in 2007. (No trapping was done in 2006.)

Pseudemys rubriventris	
2006 Visit Number (JHNWR)	**Number of basking *Pseudemys rubriventris* turtles observed**
1	6
2	0
3	0
4	0
5	0
6	0
7	2

2007 Visit Number (JHNWR)	**Number of basking turtles observed**	**Number of turtles trapped**
1	1	0
2	0	0
3	0	0
4	0	0
5	0	0
6	1	0
7	1	0
8	0	0
9	0	0
10	0	0
11	0	0
12	1	1
13	1	1
14	0	0
15	0	0
16	0	0
17	0	1
18	0	0
19	0	0
20	0	0
21	0	0
22	0	0
23	0	0
Total	5	3
Individuals		3

Table 11: Number of *C. serpentina* observed at John Heinz NWR during each visit in 2006 and 2007 compared to number trapped on each visit in 2007. (No trapping was done in 2006.)

Chelydra serpentina	
2006 Visit Number (JHNWR)	**Number of basking *Chelydra serpentina* turtles observed**
1	0
2	0
3	0
4	0
5	0
6	0
7	0

2007 Visit Number (JHNWR)	**Number of basking turtles observed**	**Number of turtles trapped**
1	0	0
2	0	0
3	0	0
4	0	1
5	0	0
6	0	1
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	0	1
17	0	0
18	0	0
19	0	0
20	0	1
21	0	0
22	0	0
23	0	0
Total	0	4
Individuals		4

Table 12: Number of turtles whose species could not be determined observed at John Heinz NWR during each visit in 2006 and 2007 compared to number trapped on each visit in 2007. (No trapping was done in 2006.)

Species undetermined	
2006 Visit Number (JHNWR)	**Number of basking turtles observed which could not be identified.**
1	0
2	0
3	0
4	0
5	0
6	0
7	0

2007 Visit Number (JHNWR)	**Number of basking turtles observed**	**Number of turtles trapped**
1	2	0
2	0	0
3	0	0
4	1	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	1	0
16	0	0
17	0	0
18	0	0
19	0	0
20	0	0
21	0	0
22	0	0
23	0	0
Total	4	0
Individuals		0

Table 13: Captures of each species on each trapping day, 2007.

Month	Day	*Trachemys scripta*	*Pseudemys rubriventris*	*Chelydra serpentina*	*Chrysemys picta*	Unknown
August	7	0	0	0	1	0
August	8	1	0	0	3	0
August	10	0	0	0	5	0
August	13	0	0	1	4	0
August	14	0	0	0	5	0
August	15	0	0	1	11	0
August	16	0	0	0	4	0
August	17	0	0	0	7	0
August	23	0	0	0	1	0
August	24	0	0	0	7	0
August	28	0	0	0	3	0
August	29	0	1	0	1	0
August	30	0	1	0	4	0
August	31	0	0	0	13	0
September	4	1	0	0	3	0
September	5	1	0	1	5	0
September	7	2	1	0	6	0
September	12	0	0	0	4	0
September	13	0	0	0	4	0
September	14	0	0	1	1	0
September	18	0	0	0	3	0
September	19	1	0	0	0	0
September	21	1	0	0	0	0
	Total captures	7	3	4	95	0
	Total Individuals	7	3	4	62	0

Table 14: Average number of turtles identified per visit using only visits where at least one turtle of any species was basking.

Wetland	*P. rubriventris*	*T. scripta*	Total	Number of Visits
Afton Lake	1	2	3	4
Blue Marsh Lake	0	0	2.67	6
Car Wash Marsh	2.75	0.25	5.75	4
Chadds Ford	0	0	3.5	4
Churchville Reservoir	0.75	1.125	5.125	8
Conewago Creek (Rte 15)	0	0	0	4
Crum Creek Reservoir	2.8	0.6	9.8	4
Delaware at Bristol	0	0	0	4
Delaware at Philadelphia	0	0	0	4
Fort Mifflin Moat	.74	.16	3.11	22
Fort Mifflin Pond	.67	1	3	5
Green Lane Reservoir	0.67	0.83	17.67	7
Green Lane Reservoir Upper	0	0	0	3
Hopewell Lake	0	0	2.25	7
Darby Creek John Heinz	0.62	1.19	8.38	3
Juniata River	20.25	0.75	25.25	4
Magnolia Lake	3	0	5	4
Lake Galena	0.7	9.3	23.7	10
Lake Marburg	0	1	5	4
Lake Nockamixon	0.2	0.2	10.4	9
Lake Onteluanee	0	0.25	4	5
Lake Warren	2.5	0	20	8
Lake Williams	0	0.33	2.33	4
Little Tinicum Island	0	0	0	3
Lower Susquehanna	0	0	1	3
Maiden Creek	0	0	0	2
Maiden Creek (Christman Lake)	0	0	1	2
Manor School Pond	3.5	0.5	4	3
Marsh Creek	0.75	0.25	7.625	8
Middle Creek Lake	0	0	20.22	4
Monocacy	0	0	0	1
Mountain Lake	12.6	0	51.67	3
Mountain Lake – Creek Road	2.5	0	20	2

Table 14 continued: Average number of turtles identified per visit using only visits where at least one turtle of any species was basking.

Wetland	***P. rubriventris***	***T. scripta***	**Total**	**Number of Visits**
Mouth of the Schuylkill	0	0	0	2
Neshaminy Creek	1	0.33	3	6
North of Hog Island Road	3	0	3	3
Northkill Creek	0	1	1	4
Penn Warner Club	1.75	0.25	4.75	3
Pennsbury Manor	1	3	5	3
Pottstown	0	0	0	6
Redman Lake	0	1	4	4
Rohm and Haas Ponds	0	2	9	3
Roosevelt Park – Meadow Lake	0.5	0	1.5	2
Roosevelt Park – Creek	0.33	3.33	4.22	4
Roosevelt Park – Edgewood Lake	4	3	7	1
Roosevelt Park – Lower Meadow	0	2	3	1
Rte 76	0	0	0	3
Silver Lake North	1.8	.8	4	5
Silver Lake South	0	1.25	3.5	4
Susquehanna River	1	0	15	1
Valley Forge Wetlands	0	0	3	8
Washington Crossing	0.8	2.2	7.2	5
Wheat Sheaf Pond	5	0	8	3

Table 15: Relative abundances for visits where at least one turtle was observed. PR/TS indicates red-bellied turtles to red-eared slider turtles. PR/Total indicates number of red-bellied turtles observed to all turtles observed. TS to total indicates number of red-eared slider turtles observed to all turtles observed.

WETLAND	PR/TS	Standard Deviation of PR/TS	PR/ TOTAL	Standard Deviation of PR/Total	TS/ TOTAL	Standard Deviation of TS/Total
Afton Lake	0.50	NA	0.33	NA	0.67	NA
Blue Marsh Lake	0.00	NA	0.00	NA	0.00	NA
Car Wash Marsh	11.00	0.17	0.48	2.32	0.04	0.02
Chadds Ford	0.00	NA	0.00	NA	0.00	NA
Churchville Reservoir	0.67	1.43	0.15	0.13	0.22	0.23
Conewago Creek (Rte 15)	0.00	NA	0.00	NA	0.00	NA
Crum Creek Reservoir	4.67	73.03	0.29	0.46	0.06	0.02
Delaware at Bristol	0.00	NA	0.00	NA	0.00	NA
Delaware at Philadelphia	0.00	NA	0.00	NA	0.00	NA
Fort Mifflin	4.00	8.00	0.15	0.31	0.04	0.02
Green Lane Reservoir	0.80	2.57	0.04	0.01	0.05	0.02
Green Lane Reservoir Upper	0.00	NA	0.00	NA	0.00	NA
Hopewell Lake	0.00	NA	0.00	NA	0.00	NA
Darby Creek John Heinz	0.52	1.45	0.07	0.05	0.14	0.13
Juniata River	27.00	738.55	0.80	4.01	0.03	0.01
Magnolia Lake	NO TS	NA	0.44	NA	0.00	NA
Lake Galena	0.08	0.02	0.03	0.01	0.39	1.48
Lake Marburg	0.00	NA	0.00	NA	0.20	NA
Lake Nockamixon	1.00	5.20	0.02	0.00	0.22	0.00
Lake Onteluanee	0.00	NA	0.00	NA	0.00	NA
Lake Warren	NO TS	NA	0.13	NA	0.00	NA
Lake Williams	0.00	NA	0.00	NA	0.14	NA
Little Tinicum Island	0.00	NA	0.00	NA	0.00	NA
Lower Susquehanna	0.00	NA	0.00	NA	0.00	NA
Maiden Creek	0.00	NA	0.00	NA	0.00	NA
Maiden Creek (Christman Lake)	0.00	NA	0.00	NA	0.00	NA
Manor School Pond	7.00	122.50	0.88	4.06	0.13	0.08

Table 15 continued: Relative abundances for visits where at least one turtle was observed.

WETLAND	PR/TS	Standard Deviation of PR/TS	PR/ TOTAL	Standard Deviation of PR/Total	TS/ TOTAL	Standard Deviation of TS/Total
Marsh Creek	3.00	51.77	0.10	0.12	0.03	0.01
Middle Creek Lake	0.00	NA	0.00	NA	0.00	NA
Monocacy	0.00	NA	0.00	NA	0.00	NA
Mountain Lake	12.67	NA	0.25	NA	0.00	NA
Mountain Lake – Creek Road	2.50	NA	0.13	NA	0.00	NA
Mouth of the Schuylkill	0.00	NA	0.00	NA	0.00	NA
Neshaminy Creek	3.00	12.00	0.33	1.57	0.11	0.20
North of Hog Island Road	NO TS	NA	1.00	NA	0.00	NA
Northkill Creek	0.00	NA	0.00	NA	0.00	NA
Penn Warner Club	7.00	26.92	0.37	2.37	0.05	0.06
Pennsbury Manor	0.33	NA	0.20	NA	0.60	NA
Pottstown	0.00	NA	0.00	NA	0.00	NA
Redman Lake	0.00	NA	0.00	NA	0.25	NA
Rohm and Haas Ponds	0.00	NA	0.00	NA	0.22	NA
Roosevelt Park – Meadow Lake	0.50	NA	0.33	NA	0.00	NA
Roosevelt Park – Creek	0.10	0.36	0.08	0.08	0.77	6.05
Roosevelt Park – Edgewood Lake	0.00	NA	0.00	NA	0.00	NA
Roosevelt Park – Lower Meadow	0.00	NA	0.00	NA	0.67	NA
Rte 76	0.00	NA	0.00	NA	0.00	NA
Silver Lake North	4.00	26.33	0.50	2.55	0.13	0.19
Silver Lake South	0.00	NA	0.00	NA	0.50	NA
Susquehanna River	1.00	NA	0.07	NA	0.00	NA
Valley Forge Wetlands	0.00	NA	0.00	NA	0.00	NA
Washington Crossing	0.36	0.08	0.11	0.08	0.31	0.90
Wheat Sheaf Pond	5.00	NA	0.63	NA	0.00	NA

Table 16: Number of turtles observed per hectare of wetland surface area. PR = *Pseudemys rubriventris*, TS = *Trachemys scripta*. PR/ha indicates the number of red-bellied turtles per hectare. TS indicates the number of red-eared slider turtles per hectare.

WETLAND	Wetland Size	PR/ha	Standard Deviation of PR/ha	TS/ha	Standard Deviation of TS/ha	total/ ha
Afton Lake	0.70	1.43	NA	2.86	NA	4.29
Blue Marsh Lake	488.50	0.00	NA	0.00	NA	0.01
Car Wash Marsh	13.50	0.20	0.25	0.02	0.04	0.43
Chadds Ford	3.64	0.00	NA	0.00	NA	0.96
Churchville Reservoir	63.40	0.01	0.02	0.02	0.02	0.08
Conewago Creek (Rte 15)	0.80	0.00	NA	0.00	NA	0.00
Crum Creek Reservoir	9.40	0.30	0.41	0.06	0.05	1.04
Delaware at Bristol	21.00	0.00	NA	0.00	NA	0.00
Delaware at Philadelphia	98.00	0.00	NA	0.00	NA	0.00
Fort Mifflin	2.10	0.95	0.00	0.24	0.34	6.19
Green Lane Reservoir	165.65	0.00	0.01	0.01	0.01	0.11
Green Lane Reservoir Upper	110.50	0.00	NA	0.00	NA	0.00
Hopewell Lake	27.65	0.00	NA	0.00	NA	0.08
Darby Creek John Heinz	138.60	0.00	0.01	0.01	0.01	0.06
Juniata River	15.10	1.34	1.17	0.05	0.10	1.67
Magnolia Lake	10.65	0.12	NA	0.00	NA	0.28
Lake Galena	147.80	0.00	0.01	0.06	0.04	0.16
Lake Marburg	474.80	0.00	NA	0.00	NA	0.01
Lake Nockamixon	297.67	0.00	0.00	0.00	0.00	0.03
Lake Onteluanee	420.25	0.00	NA	0.00	NA	0.01
Lake Warren	7.90	0.32	NA	0.00	NA	2.53
Lake Williams	68.10	0.00	NA	0.00	NA	0.03
Little Tinicum Island	75.00	0.00	NA	0.00	NA	0.00
Lower Susquehanna	2905.00	0.00	NA	0.00	NA	0.00
Maiden Creek	0.00	0.00	NA	0.00	NA	0.00
Maiden Creek (Christman Lake)	8.90	0.00	NA	0.00	NA	0.11
Manor School Pond	12.80	0.27	0.39	0.04	0.06	0.31
Marsh Creek	194.00	0.00	0.01	0.00	0.00	0.04
Middle Creek Lake	129.20	0.00	NA	0.00	NA	0.16
Monocacy	0.00	0.00	NA	0.00	NA	0.00

Table 16 continued: Number of turtles observed per hectare of wetland surface area.

WETLAND	Wetland Size	PR/ha	Standard Deviation of PR/ha	TS/ha	Standard Deviation of TS/ha	total/ ha
Mountain Lake	17.70	0.71	NA	0.00	NA	2.92
Mountain Lake – Creek Road	0.10	25.00	NA	0.00	NA	200. 00
Mouth of the Schuylkill	570.00	0.00	NA	0.00	NA	0.00
Neshaminy Creek	0.52	1.92	1.92	0.63	1.11	5.77
North of Hog Island Road	2.30	1.30	NA	0.00	NA	1.30
Northkill Creek	0.01	0.00	NA	142.86	NA	142. 86
Penn Warner Club	332.80	0.01	0.00	0.00	0.00	0.01
Pennsbury Manor	160.50	0.01	NA	0.02	NA	0.03
Pottstown	9.00	0.00	NA	0.00	NA	0.00
Redman Lake	102.20	0.00	NA	0.01	NA	0.04
Rohm and Haas Ponds	17.40	0.00	NA	0.11	NA	0.52
Roosevelt Park – Meadow Lake	5.40	0.09	NA	0.00	NA	0.28
Roosevelt Park – Creek	1.30	0.25	0.44	2.56	0.44	3.25
Roosevelt Park – Edgewood Lake	4.05	0.99	NA	0.74	NA	1.73
Roosevelt Park – Lower Meadow	1.40	0.00	NA	1.43	NA	2.14
Rte 76	0.00	0.00	NA	0.00	NA	0.00
Silver Lake North	7.90	0.34	0.39	0.08	0.15	0.67
Silver Lake South	7.90	0.00	NA	0.06	NA	0.13
Susquehanna River	2905.40	0.00	NA	0.00	NA	0.01
Valley Forge Wetlands	1.00	0.00	NA	0.00	NA	3.00
Washington Crossing	2.60	0.31	0.17	0.85	1.50	2.77
Wheat Sheaf Pond	10.90	0.46	NA	0.00	NA	0.73

Table 17: Relationship between numbers of red-bellied turtles (PR), red-eared slider turtles (TS) and rank.

WETLAND	Rank	PR/TS	PR/Total	TS/Total
Lower Susquehanna	1	1	0.00	0.00
Mountain Lake	2	12.67	0.25	0.00
Conewago Creek (Rte 15)	3	1.00	0.00	0.00
Magnolia Lake	3	1.33	0.44	0.00
Fort Mifflin Pond	3	0.75		
Redman Lake	3	0.01	0.00	0.25
Roosevelt Park – Lower Meadow	3	0.02	0.00	0.67
Silver Lake North	3	6.13	0.00	0.50
Susquehanna River	3	10.00	0.07	0.00
Mountain Lake – Creek Road	4	25.00	0.13	0.00
Penn Warner Club	4	8.50	0.37	0.05
Pennsbury Manor	4	0.33	0.20	0.60
Juniata River	5	27.00	0.80	0.03
Maiden Creek (Christman Lake)	5	1.00	0.00	0.00
Neshaminy Creek	5	30.00	0.33	0.11
Rte 76	5	1.00	0.00	0.00
Wheat Sheaf Pond	5	50.00	0.63	0.00
Monocacy	6	1.00	0.00	0.00
Mouth of the Schuylkill	6	1.00	0.00	0.00
Blue Marsh Lake	7	1.00	0.00	0.00
Car Wash Marsh	7	11.00	0.48	0.04
Darby Creek – John Heinz	7	0.52	0.07	0.14
Lake Onteluanee	7	1.00	0.00	0.00
Lake Williams	7	0.01	0.00	0.14
Manor School Pond	7	7.00	0.88	0.13
Middle Creek Lake	7	1.00	0.00	0.00
North of Hog Island	7	30.00	1.00	0.00
Rohm and Haas Ponds	7	0.02	0.00	0.22
Valley Forge Wetlands	7	1.00	0.00	0.00
Crum Creek Reservoir	8	4.67	0.29	0.06
Lake Galena	8	0.08	0.03	0.39
Lake Marburg	8	0.01	0.00	0.20
Lake Nockamixon	8	1.00	0.02	0.22

Table 17 continued: Relationship between numbers of red-bellied turtles (PR), red-eared slider turtles (TS) and rank.

WETLAND	Rank	PR/TS	PR/Total	TS/Total
Marsh Creek	8	3.00	0.10	0.03
Pottstown	8	1.00	0.00	0.00
Roosevelt Park – Edgewood Lake	8	1.00	0.00	0.00
Afton Lake	9	0.50	0.33	0.67
Churchville Reservoir	9	0.67	0.15	0.22
Delaware at Bristol	9	1.00	0.00	0.00
Little Tinicum Island	9	1.00	0.00	0.00
Roosevelt Park – Creek	9	0.33	0.08	0.77
Silver Lake North	9	4.00	0.50	0.13
Chadds Ford	10	1.00	0.00	0.00
Fort Mifflin	10	4.00	0.15	0.04
Green Lane Reservoir	10	0.80	0.04	0.05
Northkill Creek	10	1.00	0.00	0.00
Roosevelt Park – Meadow Lake	10	0.50	0.33	0.00
Delaware at Philadelphia	11	1.00	0.00	0.00
Washington Crossing	11	0.36	0.11	0.31
Hopewell Lake	12	1.00	0.00	0.00
Lake Warren	12	2.50	0.13	0.00

Table 18: Sightings of red-eared slider turtles, *T. scripta elegans*, and red-bellied turtles, *P. rubriventris* at sites with documented occurrence of red-bellied turtles in Southeastern Pennsylvania, 2006 and 2007 field seasons.

Wetland Name	Park	County	Easting Northing	Total *T. scripta*	Total *P. rubriventris*	Total Unknown
Afton Lake	N	Bucks	513622 4454487	2	1	0
Blue Marsh Lake	Y	Berks	407421 4474298	0	0	3
Car Wash Marsh	N	Delaware	476893 4413757	1	9	9
Chadds Ford	N	Delaware	449343 4413522	0	0	1
Churchville Reservoir	Y	Bucks	500038 4448539	9	6	4
Conewago Creek (Rte 15)	N	Adams	315948 4422133	0	0	0
Crum Creek Reservoir	N	Delaware	468612 4419398	3	14	25
Darby Creek John Heinz	Y	Delaware and Philadelphia	477743 4415808	3	8	0
Delaware at Bristol[1]	Y	Bucks	512819 4438047	0	0	0
Delaware at Philadelphia[1]	Y	Philadelphia	488089 4421988	0	0	0
Fort Mifflin	Y	Philadelphia	476437 4411889	1	4	3
Green Lane Reservoir Lower	Y	Montgomery	458862 4464692	5	4	9
Green Lane Reservoir Upper	Y	Montgomery	457603 4469715	0	0	0
Hopewell Lake	Y	Berks	432779 4450055	0	0	1
John Heinz	Y	Delaware and Philadelphia	477743 4415808	24	5	4
Juniata River	N	Perry	329196 4477342	3	81	0
Lake Galena	Y	Bucks	485578 4465188	51	2	7
Peach Valley	Y	Bucks	485497 4432149	42	5	0
Lake Marburg	Y	York	336077 4405710	2	0	0
Lake Nockamixon	Y	Bucks	482675 4483046	1	1	0
Lake Onteluanee	Y	Berks	422429 4477899	1	0	1
Lake Warren	Y	Bucks	486985 4487571	0	5	3
Lake Williams	Y	York	352837 4416762	1	0	0

Table 18 Continued

Wetland Name	Park	County	Easting Northing	Total *T. scripta*	Total *P. rubriventris*	Total Unknown
Little Tinicum Island[1]	Y	Delaware	476439 4411886	0	0	0
Lower Susquehana	N	Lancaster or York	371689 4431632	0	0	1
Magnolia Lake	N	Bucks	511742 4440794	0	4	0
Maiden Creek[1]	N	Berks	425155 4491345	0	0	0
Maiden Creek (Christman Lake)[2]	N	Berks		0	0	0
Manor School Pond	N	Bucks	515404 4446573	1	7	0
Marsh Creek	Y	Chester	438033 4437168	2	6	5
Middle Creek Lake	Y	Lancaster	394648 4457864	0	0	2
Monocacy[1]	N	Adams	296807 4408151	0	0	0
Mountain Lake	N	Franklin	258975 4438146	0	38	0
Mountain Lake – Creek Road	Y	Franklin	4438145	0	5	5
Mouth of the Schulykill[1]	N	Philadelphia	482559 4450724	0	0	0
Neshaminy Creek	N	Bucks	497020 4456448	1	3	2
North of Hog Island Road	N	Delaware	479404 4412328	0	3	0
Northkill Creek[2]	N	Berks	403384 4478061	0	0	0
Penn Warner Club Site	N	Bucks	518633 4445030	1	7	5
Pennsbury Manor	N	Bucks	518019 4443149	3	1	0
Pottstown[1]	N	Chester / Montgomery	444562 4454598	0	0	0
Redmand Lake	Y	York	354659 4416439	1	0	3
Rohm and Haas Ponds	N	Bucks	511624 4437353	2	0	7
Roosevelt Park – Creek	Y	Philadelphia	484307 4416664	10	1	1
Roosevelt Park – Edgewood Lake	Y	Philadelphia	484566 4417099	3	4	0

Table 18 continued

Wetland Name	**Park**	**County**	**Easting Northing**	**Total *T. scripta***	**Total *P. rubriventris***	**Total Unknown**
Roosevelt Park – Lower Meadow	Y	Philadelphia	484689 4416907	2	0	0
Roosevelt Park – Meadow Lake	Y	Philadelphia	484508 4416882	0	1	0
Rte 76[1]	N	Chester	433227 4442163	0	0	0
Silver Lake North	Y	Bucks	511924 4440145	2	8	1
Silver Lake South	Y	Bucks	511575 4439036	1	0	0
Susquehanna River	N	Juniata	372146 4426776	0	1	14
Valley Forge	Y	Montgomery	460119 4439763	0	0	7
Washington Crossing	Y	Bucks	519425 4442676	11	4	7
Wheat Sheaf Pond	N	Bucks	516616 4445167	0	5	3

1: No turtles observed at this site

2: One *C. picta* observed.

Table 19: List of sites where *Pseudemys rubriventris* were observed. Data are from 2005-2007 and 2009 seasons. Asterisks identify macrosites, or the combined results from several interconnected areas of a wetland. For example, the Silver Lake North and Silver Lake South sites are part of the same body of water.

Sites where only *P. rubriventris* were identified			
Wetland	**County**	**Township**	**Watershed**
Magnolia	Bucks	Bristol	Crosswicks-Neshaminy
Lake Warren	Bucks	Riegelsville	Middle Delaware-Musconetcong
Wheat Sheaf Pond	Bucks	Trenton West	Crosswicks-Neshaminy
North of Hog Island Road	Delaware	Woodburry and Bridgeport	Lower Delaware
Mountain Lake	Franklin	Fannettsburg	Conococheague-Opequon
Mountain Lake – Creek Road	Franklin	Fannetsburg	Conococheague-Opequon
Susquehanna River	Lancaster	Manor	Lower Susquehanna
Roosevelt Park – Meadow Lake	Philadelphia	Philadelphia	Schuylkill

Table 20: List of sites where *Trachemys scripta* were observed. Data are from 2005-2007 and 2009 seasons. Asterisks identify macrosites, or the combined results from several interconnected areas of a wetland. For example, the Silver Lake North and Silver Lake South sites are part of the same body of water.

Sites where only *T. scripta* were identified			
Wetland	**County**	**Township**	**Watershed**
Lake Onteluanee	Berks	Ontelaunee	Schuylkill
Rohm and Haas Ponds	Bucks	Bristol	Crosswicks-Neshaminy
Silver Lake South	Bucks	Bristol	Crosswicks-Neshaminy
Roosevelt Park – Lower Meadow	Philadelphia	Philadelphia	Schuylkill
Lake Marburg	York	Hannover	Lower Susquehanna
Lake Williams	York	York	Lower Susquehanna
Redman Lake	York	York	Lower Susquehanna

Table 21: List of sites where both species were observed. Data are from 2005-2007 and 2009 seasons. Asterisks identify macrosites, or the combined results from several interconnected areas of a wetland. For example, the Silver Lake North and Silver Lake South sites are part of the same body of water.

Sites where both species were identified			
Wetland	**County**	**Township**	**Watershed**
Lake Nockamixon	Bucks	Bedminster	Middle Delaware-Musconetcong
Silver Lake North	Bucks	Bristol	Crosswicks-Neshaminy
Silver Lake Nature Center*	Bucks	Bristol	Crosswicks-Neshaminy
Neshaminy Creek	Bucks	Buckingham	Crosswicks-Neshaminy
Lake Galena	Bucks	Doylestown	Crosswicks-Neshaminy
Pennsbury Manor	Bucks	Falls	Crosswicks-Neshaminy
Washington Crossing	Bucks	Lambertville	Middle Delaware-Musconetcong
Churchville Reservoir	Bucks	Langhorne	Crosswicks-Neshaminy
Afton Lake	Bucks	Trenton West	Middle Delaware-Musconetcong
Manor School Pond	Bucks	Trenton West	Crosswicks-Neshaminy
Penn Warner Club Site	Bucks	Trenton West	Crosswicks-Neshaminy
Marsh Creek	Chester	Downingtown	Brandywine-Christina
Car Wash Marsh	Delaware	Bridgeport and Lansdowne	Lower Delaware
Crum Creek Reservoir	Delaware	Lansdowne	Lower Delaware
Darby Creek - John Heinz National Wildlife Refuge	Delaware and Philadelphia	Bridgeport and Lansdowne	Lower Delaware
Impoundment - John Heinz National Wildlife Refuge	Delaware and Philadelphia	Bridgeport and Lansdowne	Lower Delaware
John Heinz National Wildlife Refuge*	Delaware and Philadelphia	Bridgeport and Lansdowne	Lower Delaware
Green Lane Reservoir Lower	Montgomery	Perkiomenville	Schuylkill

Sites where both species were identified			
Wetland	**County**	**Township**	**Watershed**
Green Lane Reservoir*	Montgomery	Perkiomenville	Schuylkill
Juniata River	Perry	Duncannon	Lower Juniata
Fort Mifflin Moat	Philadelphia	Philadelphia	Lower Delaware
Fort Mifflin Pond	Philadelphia	Philadelphia	Lower Delaware
Fort Mifflin*	Philadelphia	Philadelphia	Lower Delaware
Roosevelt Park – Creek	Philadelphia	Philadelphia	Schuylkill
Roosevelt Park - Edgewood Lake	Philadelphia	Philadelphia	Schuylkill
Roosevelt Park*	Philadelphia	Philadelphia	Schuylkill

Table 22: List of sites where neither species was observed, but other turtles were seen. Data are from 2005-2007 and 2009 seasons. Asterisks identify macrosites, or the combined results from several interconnected areas of a wetland. For example, the Silver Lake North and Silver Lake South sites are part of the same body of water.

Sites where neither species was identified			
Wetland	**County**	**Township**	**Watershed**
Hopewell Lake	Berks	Elverson	Schuylkill
Christman Lake	Berks	Hamburg	Schuylkill
Maiden Creek and Christman Lake*	Berks	Hamburg	Schuylkill
Blue Marsh Lake	Berks	North Heidelberg	Schuylkill
Northkill Creek	Berks	Strausstown	Schuylkill
Chadds Ford	Delaware	Wilmington North	Brandywine-Christina
Lower Susquehanna	York	Lower Windsor	Lower Susquehanna
Middle Creek Lake	Lancaster	Womelsdorf	Lower Susquehanna
Valley Forge Wetlands	Montgomery	Valley Forge	Schuylkill

Table 23: List of sites where no turtles were observed. Data are from 2005-2007 and 2009 seasons. Asterisks identify macrosites, or the combined results from several interconnected areas of a wetland. For example, the Silver Lake North and Silver Lake South sites are part of the same body of water.

Sites where no turtles were seen			
Wetland	**County**	**Township**	**Watershed**
Conewago Creek (Route 15)	Adams	Bilgerville	Lower Susquehanna
Monocacy	Adams	Hamiltonban	Monocacy
Maiden Creek	Berks	Hamburg	Schuylkill
Delaware River at Bristol	Bucks	Bristol	Crosswicks-Neshaminy
Route 76	Chester	Wagontown	Brandywine-Christina
Pottstown	Chester and Montgomery	Pottstown	Schuylkill
Little Tinicum Island	Delaware	Woodburry and Bridgeport	Lower Delaware
Green Lane Reservoir Upper	Montgomery	Perkiomenville	Schuylkill
Delaware River at Philadelphia	Philadelphia	Philadelphia	Lower Delaware
Mouth of the Schuylkill	Philadelphia	Philadelphia	Schuylkill

Appendix B: Data Sheets

Drexel University Distribution of Red-eared Slider Turtles and Habitat Evaluation Field Form (revised 10 May 2006)

Waterbody Description

Wetland Name: Observation Site Number:
County: USGS Quad:
Township / Municipality:
Investigator Names: Investigator Affiliation:

Lake ☐ Pond ☐ Stream ☐ Marsh ☐ River ☐ Other ☐ Approx. Size: ______________ (ha)

Photos Taken? Yes ☐ No ☐ Shoreline Development? ☐Yes ☐No Type:

Accessability Characteristics At Observation Site (Check All Boxes That Apply):

Public Park ☐ Hiking Trail to Site ☐ Paved Road to Site ☐ Dirt Road to Site ☐ People at Site During Survey ☐ Estimated Distance Site to Nearest Paved Road (km) ____ Access Note(s): ________

Est. Shoreline Length (km or m - circle one): Water Depth (m):
UTM Easting: ______________________ UTM Northing: ______________________ Elevation (m):
Latitude: Longitude:

Survey Date and Conditons

Date: Time Arrival: Time Departure:
Air Temp. (°C) Water Temp. (°C) Cloud Cover: %)
Wind Speed (km/hr): Direct Vehicle Access? ☐Yes ☐No

Habitat Characteristics

No. Basking Objects at Site: How Much of Wetland is Visible from Road?
No. Basking Objects Used: _____________ ☐ All ☐ Part ☐ None
Types of Basking Objects:
Distance to Nearest Wetland: __________ (km)

Description of Wetland Vegetation (Describe Veg. Life Forms or Dominant Species for Each Zone)

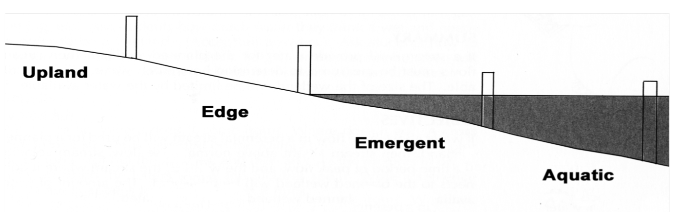


Figure 24: Observation data sheet – wetland characteristics.

Number of Turtles Observed Basking by Species

Species Name	No. Hatchlings	No. Subadults	No. Adults	Time Observed	Basking Substrate
Trachemys scripta					
Pseudemys rubriventris					
Chrysemys picta					
Chelydra serpentina					
Sternotherus odoratus					
Other (Specify)					

Additional Comments / Observations (Please Print Clearly)

Figure 25: Observation data sheet – number, species and stage class of turtles.

Drexel University Silver Lake Nature Center

Turtle Trapping Activity Record

PA Fish and Boat Commission Grant

2008 Field Season

Today's Date______________ Personnel _________________________

Climatic Conditions (Clouds,wind,etc..)______________

Name of Aquatic Area ____________________

Water Temp Min.________ Water Temp. Max________

GPS Coordinates of Trap (UTM,Meters)	Date Trap Set	Time Trap Checked	Trap #	Type Trap	Type of Bait	Total # Turtle	# red-bellied	# New
Easting Northing								
Easting Northing								
Easting Northing								
Easting Northing								
Easting Northing								
Easting Northing								
Easting Northing								
Easting Northing								
Easting Northing								
Easting Northing								

Comments, Maps etc.

Figure 26: Trapping data sheet – trap locations.

Red-eared Slider / Red-bellied Turtle Grant Capture Form
Drexel University 200[illegible] Field Season

Date (Month/Day/Year) Time (mil):

Field Personnel: Recorder(s):

Capture Location: Capture Location Details:

Capture Method: Bait Used:

Species: Water temp: C

Weather Conditions: Sunny / Pt. Cloudy / Mostly Cloudy / Overcast / Rain Air Temp: C

GPS Reading: Easting: Northing:

Captured by (names): Trap #:

Morphometrics:

Carapace length mm Carapace width mm

Plastron length mm Carapace height mm Weight

General Information:

Sex: Male Female Juvenile Age (if applicable): Rel. (1,2,3)

Previously Captured: Y or N If so, Notch Designation PIT Tag #

Newly Captured Notch Designation: PIT Tag#

Carapace Comments:

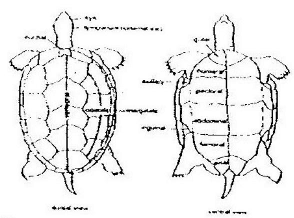
Plastron Comments:

Body Condition / Injuries: (limbs, tail, head):

Number Marginal Scutes __

Number Costal Scutes __

(Draw Injuries on figures)



Other Distinguishing Features? (Y or N): __

Describe:

Capture/Release Information:

Captured alive: Y or N Released alive: Y or N Release Time:

Released same date? Y or N If not, date released:

Treatment Methods (if applicable):

Was turtle used for x-radiography? Y or N Was female gravid? Y or N Clutch Size

Notes:

(Avery Dre[illegible]

Figure 27: Trapping data sheet – individual turtle capture information.